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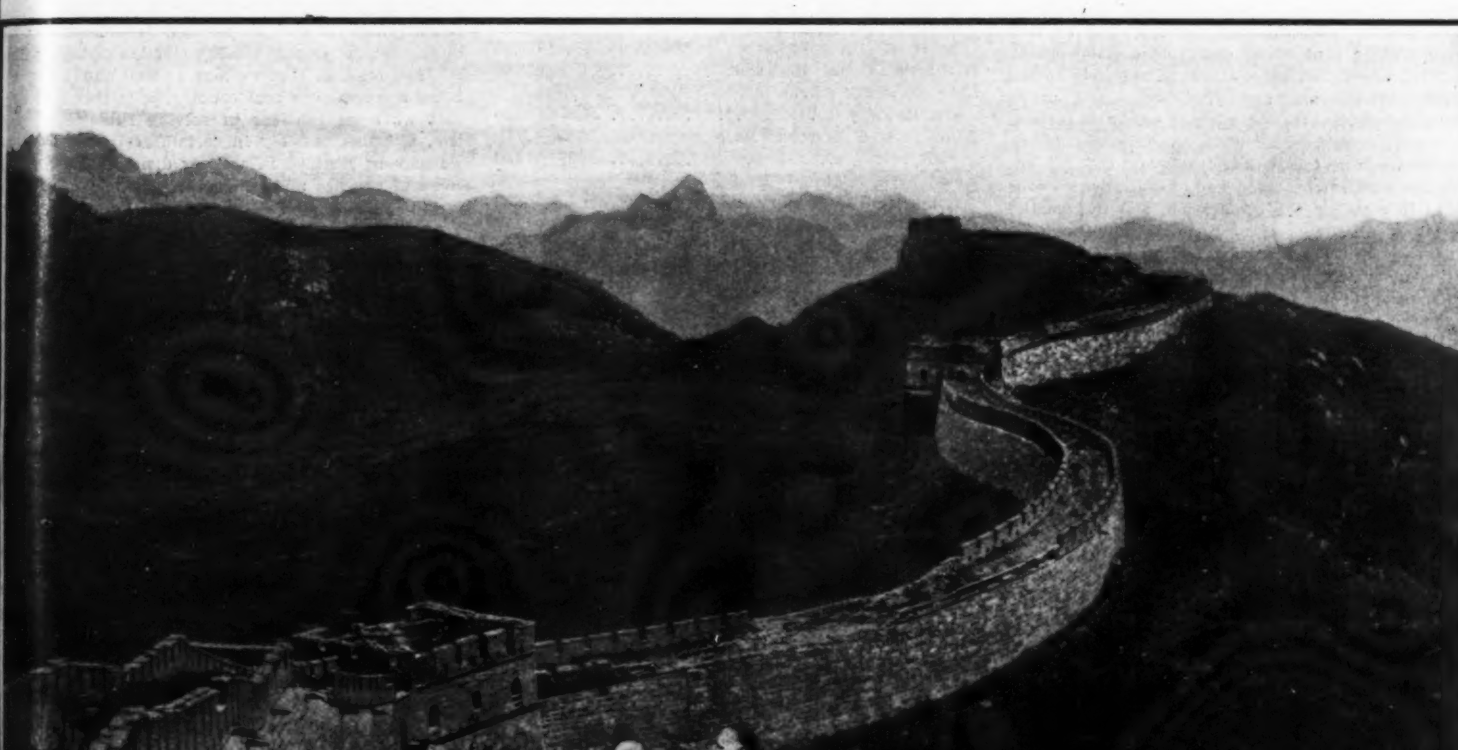
EXPLORING THE GREAT WALL OF CHINA.

By Dr. William Edgar Geil.

The Great Wall of China, which even to this day represents the original idea of Chin, the first emperor, has had an uninterrupted existence for over 2,100 years. It has often been in decay, but successive dynasties have repaired it and added to it, thus preserving the identity of the greatest wall of human history. Chin seems to have contemplated inclosing the whole country by a massive rampart in the form of a horse-



A UNIQUE VIEW OF A HITHERTO UNVISITED PORTION OF THE GREAT WALL AT LIEN HUA CHIH.

EXPLORING THE GREAT WALL OF CHINA.

[sho]e with the heel calks at the sea, but he died before [the] design was finished.

[Th]e stupendous fabric stretches its protecting length [fro]m the Yellow Sea to the Yellow River and thence [ove]r the yellow earth (loess) and the yellow sands [to a] point north of the Nan Shan range. Beginning [belo]w the level of the ocean the Great Wall ascends [to a]n altitude of nearly two miles above the tide. We [hav]e traveled along this wall a distance of over 1,800 [mile]s. We found it unnecessary to examine every [yar]d of every loop, but for weeks at a time there was [not] a day when the Great Wall was not under our [obse]rvation. This, if we are correctly informed, was [the] first journey ever taken along the wall.

[W]e have found records describing the operations [o]n towers and first, second, and third class walls [bein]g erected. The work of the engineers, masons, [bla]cksmiths, and in the later walls geomancers, pro[vide]s a most entrancing illumination of how the wall [was] put up. The towers were built first, wells dug [and ci]sterns constructed, and then the curtain walls in[terpose]d and connecting links.

The illustration here given shows one type of tower and curtain walls. The towers contain three or four windows according to their style. The illustration affords a good example of the finely-constructed curved walls which are to be met with at intervals along the Great Wall.—The Sphere.

POPULATION OF THE AMERICAN COLONIES.

Thirty-eight enumerations of the various colonies were made in all by the government, but no enumeration embraced all the colonies. In several, indeed, no accurate count of population occurred during the entire colonial period.

The first population in a decennial year (which may be regarded as continuous) was that of Virginia, in 1610, consisting of 200 souls maintaining a precarious foothold upon an unexplored continent; after the lapse of approximately two centuries, there was an aggregate population of 3,900,000 occupying more than 800,000 square miles in territory. In 1650 more than half of the inhabitants were in the New England colonies and most of the remainder in Virginia; but from that date the proportion in New England steadily declined, and the proportion in the southern colonies increased.

Three cities—New York, Philadelphia, and Boston—have continued to the present time to be leaders, not only in the number of their inhabitants, but also in prosperity and influence. From its foundation in 1630 until the middle of the eighteenth century, Boston was the most populous town in the American colonies. Philadelphia (including suburbs) then took the lead, which it retained until it in turn was passed by New York, after the establishment of the constitutional government. Hence each of these three cities at some period has been the leader in population.

All of the great area lying south of the Potomac must be regarded as having been distinctly rural in the colonial period. In North Carolina, one of the larger commonwealths, even as late as 1790 no community existed in which the population exceeded 2,000 inhabitants.

In 1700 the aggregate population of the three leading cities—Boston, New York, and Philadelphia—was approximately 15,500. Ninety years later the aggregate population of these three cities was 95,000, having increased sixfold. In 1900 the population of the three cities mentioned was 5,291,791. An increase of 80,000 in the first century of existence is therefore to be compared with an increase of 5,200,000 in the second.

In 1897 the Italian Society for the Study of Malaria began its work of eradicating malaria, with the result that in 1907 the number of victims of the fever was only 4,160, or fewer than one-fifth as many as twenty years before. This reduction of mortality was effected not by systematic drainage as might be supposed, but by the gratuitous, wholesale administration of quinine. Drainage was impracticable, if not impossible, because the mosquito-ridden area is too extensive. Quinine administration, at first sight, must appear merely as a temporary remedy. It must not be forgotten, however, that the mosquito is not so much the originator as the carrier of the disease, and that until it has bitten a fever-stricken patient, it is harmless.

THE SMOKE NUISANCE AND THE RAILROADS.[*]

CONSIDERED FROM THE ECONOMICAL AND GEOLOGICAL STANDPOINT

BY A. W. GIBBS.

With the railroads of this country, the prime essential in manufacturing cheap transportation is the possibility of hauling large train units. In this, we differ radically from the railroads of other countries, with which comparisons are most frequently made; that is to say, more frequent and lighter units are the rule. This means that in this country the locomotive has developed into a power plant of the most concentrated character. For instance, where with a stationary plant we are satisfied to burn from 15 to 20 pounds of coal per square foot of grate surface per hour, in many of our locomotives we must be able to burn not less than 100 pounds of coal per square foot of grate surface within the same period of time. In a stationary plant, fluctuations in the demands are comparatively slight and can usually be anticipated and prepared for in advance, while with the locomotive, on the other hand, we must be able to vary the output enormously within an extremely short period of time. For instance, a locomotive may be working at full power, producing little smoke, and be suddenly forced to shut off or stop, under which condition the fire will not adapt itself immediately to the changed requirements, and even with care, under such circumstances, the emission of smoke is certain. The reason for this is that while working with forced draft, there is a fair balance between the rate at which the coal is consumed and the air drawn over the fire to complete the combustion, and the volatile material is distilling off at a fairly uniform rate. With the cessation of the draft, but with the coal still emitting quantities of volatile gases, air is not drawn in in sufficient quantity, with the result so frequently experienced. Again, many coals which when burned in a leisurely manner give little or no visible smoke, will give great annoyance when the rate of combustion is doubled or trebled as the case may be. Consequently, it may reasonably be expected that the terminals in level country, where trains can be handled in and out of the station without excessive demands on the locomotive, are likely to be more nearly smokeless than those where the locomotive must be overworked from the start.

LIMITATIONS OF SIZE.

Limitations of space, such as width of gage, tunnels, bridges and other clearances, restrict us in the possible dimensions of the locomotive power plant; consequently, the whole plant—particularly the boiler—is operated at an intensity nowhere else required. This is the crux of the whole situation, for while it is possible to burn almost any fuel smokelessly, provided the operation be not too hurried, it requires considerable skill and the best appliances to do so when the rate of combustion is forced to the utmost.

The question may now very properly be asked, how do the conditions of the present day differ from those of the past, and why is this question of smoke prevention more important now than ever before?

In answer to this it may be stated: First, that while the design of the locomotive in its essential details differs but slightly from the older types, there has been a great increase in the number and size of the locomotives and in the demands made on them. Secondly, it is to be noted that the complaints against smoke usually come from cities and towns, rather than from the country. This is natural, for the reason that there are more people and more locomotives at the terminal, and it is just there that conditions are naturally the worst, for it is at the terminals where old fires must be cleaned and new ones started. It is then, of all times, that smoke is most unavoidable. It is also true that many railroads have built their terminals in what was then the country, but cities have grown up around them, and with the growth come the complaints. The public demands facilities in the heart of business centers, in order to cheapen drayage and afford convenient access for travelers.

FUEL AVAILABLE.

It is evident that the railroads must produce power with the fuel of the country through which they run, and a glance at a geological map of this country will convince anyone that bituminous coal is that with which this question must be settled. Anthracite is confined to practically a few counties in the eastern part of Pennsylvania. The amount of anthracite mined is a trifle more than 70,000,000 tons each year. It is the ideal fuel for domestic purposes and use in plants where its cost is not prohibitive. The total amount is so limited, however, that were the demand to be on this fuel alone, the supply would be inadequate. In illustration of which we submit the following statement of the consumption for the fiscal year ending June 30th, 1907, on twenty railroads, which, from their geographical location, would naturally have the first claims on this fuel, for the reason that they are nearest the anthracite field, viz.:

	Anthracite (Tons).	Bituminous (Tons)
Pennsylvania Railroad Company	61,297.25	7,159,627.55
Pennsylvania Company	....	2,128,994.00
Northern Central Railway	22,364.00	604,856.00
Philadelphia, Baltimore & Washington R. R.	....	637,765.45
Long Island Railroad	156,494.84	155,618.52
Pittsburgh, Cincinnati, Chicago & St. Louis Ry	....	1,758,501.00
Baltimore & Ohio Railroad	20,451.05	4,782,434.25
New York Central & Hudson River R. R.	216,624.00	4,242,476.00
Michigan Central Railroad	....	1,245,628.00
Lake Shore & Michigan Southern Railway	....	1,998,902.00
Lake Erie & Western Railroad	....	300,613.00
New York, Chicago & St. Louis Railroad	....	539,614.00
Central Railroad of New Jersey	607,617.00	318,348.50
Delaware & Hudson Company	902,769.00	196,183.00
New York, New Haven & Hartford Railroad	34,268.00	1,830,701.00
Boston & Maine Railroad	....	1,440,454.00
Erie Railroad	263,158.00	2,216,058.00
Philadelphia & Reading Railway	1,145,134.70	903,565.10
Lehigh Valley Railroad	835,398.51	99,065.36
Delaware, Lackawanna & Western Railroad	1,312,907.00	342,142.00

MIXED COALS NOT SMOKELESS.

These roads consume annually some 39 3/10 million tons, 5½ million tons of which are anthracite. It will be observed that some of the anthracite roads use considerable amounts of bituminous coal. In many cases this bituminous coal is used as an admixture in order to make it possible to burn under locomotive conditions, the very small sizes of anthracite otherwise not available. This mixture of two coals is not smokeless. Assuming that the entire consumption of these roads were anthracite, it will be seen that this small group alone would consume more than one-half of the total amount of anthracite mined. While such action would doubtless stimulate the production, it would but hasten the disappearance of this most valuable fuel, to say nothing of the enhancement in price which would most assuredly follow and directly affect every householder now dependent on this fuel. Granting that the anthracite thus absorbed by the railroads were replaced by bituminous coal for domestic purposes, the smoke situation would be far worse than at present because the numerous small domestic fires, with the usually imperfect combustion, produce more total smoke than would the same amount of bituminous coal burned in locomotive furnaces. The item of cost to the railroads would be such a tremendous increase in their expenses as to make it absolutely prohibitive. A recent study of this subject showed that on nineteen of the principal roads, the fuel bill exceeded 11.4 per cent of the total operating expense, or nearly 8 per cent of the gross earnings.

COKE.

The total production of coke is about 36 million tons annually, which is almost entirely used in metallurgical work, for which there is no substitute. While it may be admitted that the production of coke could be largely increased, it should be remembered that in the production of coke from bituminous coal, there is an initial waste of about one-third of the heating value of the fuel, with further losses from breakage in handling, it is evident that this attempted solution would be an unpardonable waste of our natural resources.

However, in the endeavor to obviate smoke, a great many attempts have been made to use coke, and the records of the tests show that the results have been very unsatisfactory, owing to the difficulty with which the fuel is handled, at times the heat being entirely too intense and at others the fire being almost stopped up by the ashes produced. It must not be forgotten that in the process of burning coal to coke, the ash originally in the coal remains in the coke, so that in burning a ton of coke, much more ash results than from the consumption of a ton of the coal from which it was made. The coke, when used, is satisfactory in but one particular, namely, its freedom from smoke.

The reason that anthracite and coke are smokeless is because of the large percentage of fixed carbon and the small percentage of volatile or flame-and-smoke producing material. For instance, the fixed carbon may run as high as 90 per cent, volatile matter not over 4 per cent; the remainder being ash and sulphur.

BITUMINOUS COAL.

Of bituminous coal, somewhat over 400,000,000 tons are mined annually, and the total consumption of this fuel by the railroads of this country is estimated to closely approximate 100,000,000 tons. This railroad consumption, it will be noticed, is almost sufficient to exhaust the present total production of both anthracite and coke, so that we may as well admit that this being a bituminous coal country, it is this fuel alone that we must consider in solving this smoke problem, although possibly in certain restricted localities we may be justified in entirely disregarding all questions of expense and using only smokeless fuel; this for the sole purpose of controlling the smoke.

BRIQUETTES.

A possibility of the future, not yet fully developed, is the use of smokeless or low-volatile coals made into briquettes by the addition of suitable binding material, after which the fuel is pressed into large blocks. This practice, long known and utilized abroad, is now being developed in this country, very intelligent work being done by the United States Geological Survey, and while at present the cost of fuel so produced is so high as to be prohibitive, it is hoped that this method of preparing fuel may ultimately prove a factor in relieving the smoke nuisance. The conservation of our natural resources makes it imperative that we should be able to utilize all sizes and kinds of coal, so that instead of selecting the best of the coal and leaving the inferior grades in the mine, the vein which is being mined should have all the fuel removed, as otherwise, the settling of the ground causes the total loss of all the unmined fuel. To the extent that briquetting helps to attain this result, its extension is desirable.

OIL FUEL.

Oil fuel is largely used in some parts of the Southwest, where there are great deposits of oil, otherwise of little value. Owing to the distance and the difficulties of transportation, it is not likely that this fuel can be considered as one available for railroads other than those in the territory where such oil abounds, and may be dismissed from our consideration.

To recapitulate: Anthracite, coke and low-volatile bituminous coal are all being used, to a greater or lesser extent, at various points where the smoke condition is most pronounced, in order to minimize the annoyance, but, as has been pointed out, the extension of the use of such fuels is distinctly limited, and the great question remains: By what appliances or methods, without annoyance to the community, shall we successfully burn the bituminous coal which must be our reliance?

REQUIREMENTS FOR SMOKELESS COMBUSTION.

There is probably no railroad of importance which has not from time to time introduced appliances for this purpose. The basis on which such devices are planned is as follows:

First.—To distill the volatile gases at as uniform a rate as possible.

Second.—To present to the burning gases an adequate supply of air to effect complete combustion.

Third.—To thoroughly mix this air with the gases.

Fourth.—To effect this mixture while the gases are still at a very high temperature.

Fifth.—To allow sufficient time for this mixture and combustion of the air and gases to take place before the heat is absorbed and the temperature reduced below the combustion point.

With these five conditions complied with, the whole difficulty is overcome, and just in so far as the devices meet these five conditions are they successful.

DEVICES.

A bare mention of all these devices would be tedi-

* Abstracted from a paper prepared in response to a request from the American Civic Federation.

ous, but it may not be amiss to indicate some of the methods by which this has been attempted.

The first condition is the manual one of introducing the coal steadily and in small quantities, preferably allowing it to coke near the door.

The brick arch placed across the lower forward end of the firebox and inclined upward and toward the rear, to act as a baffle to increase the distance that the burning gases must flow before the cooling of the flame is effected. In this process, the arch becomes intensely hot, thus maintaining the high temperature while the fire-door is momentarily opened. This device partly meets conditions 4 and 5, and when supplemented by judicious air admission above the fire, partly meets the last four conditions. This, one of the oldest devices, is probably the best and was once the general standard for locomotives of the Pennsylvania and other railroads. The reason why it was not maintained is that its presence in the firebox is a very serious obstacle to the proper and frequent inspection of the interior, on the perfection of which examination safety hinges. The arch remains incandescent for a long period, thus making proper inspection impracticable. The other reason for its disuse is that the locomotive is a power plant of such concentrated character and so highly forced that the arch alone without very intelligent firing will not prevent smoke. To illustrate, it is perfectly practicable to operate at moderate power with such an absence of smoke that for periods of more than one-half hour not a particle of smoke will be visible, but let the conditions change, now shutting off, now working to the utmost limit of capacity, and smoke at once appears because the device will not adapt itself to these extreme conditions.

Other devices embody one or more of the following: Air pipes through the sides of the firebox to admit air to meet conditions 2 and 3; this is only partially effective. Again, air pipes more or less exposed to the heat of the fire so as to preheat the air, are tried, thus attempting to meet conditions 2, 3 and 4. The difficulty with this type is that the heat of the fire usually destroys the device. Still others employ steam jets, sometimes superheated, to thoroughly mix the gases and comply with conditions 2 and 3. Then there is the constantly recurring attempt to bring back to the firebox some of the smokebox gases, as well as the partly burned cinders there collected. This has never been developed to an extent to afford any promise.

AUTOMATIC STOKERS.

In this connection, while considering devices, we cannot omit all reference to the question of automatic stokers. The general progress demands transferring the burden of great manual exertion from the man to a machine, the latter doing the hard work and the man supervising the action of the machine. With this end in view, a great deal has been and is being done in the direction of developing automatic stokers which will do the firing with a certain amount of manual supervision. Of these devices, quite a number have been devised and put into use on locomotives. So far, they have not proven satisfactory and, from their imperfection, have not improved the smoke conditions, but the demand for them is so urgently recognized by the railroads, not only from the mere smoke question, but also on account of the saving in money and relief to labor, that there is ground for hope that in the comparatively near future a satisfactory automatic stoker will be developed. The problem is a most difficult one, and at present some of the brightest and most practical minds are at work on a solution, and although it is difficult to predict how soon success may be attained, it is certain that decided progress is being effected.

The automatic stoker, when perfected, promises to be one of the most effective appliances to aid in the suppression of smoke, for the reason that it does not become tired from the hard work and, consequently, should do as well after hours of service as in the beginning; the contrary is the case with the man. For this reason, the stoker, when perfected, will come to stay.

The gist of the matter is that devices alone, unless supplemented by intelligent and unremitting attention, never long survive. They start with a flare of trumpets; they show a decided improvement over previous conditions; then less is heard of them; and, finally, when inquiry is made, it is found that they have been removed as inefficient. The real reason is, that while new they received a degree of attention that makes them more or less successful, and the credit is ascribed largely to the device when it is actually due to the care.

Evidently, the real line of progress is to stimulate and maintain the intelligent care, and it is in the latter direction that the most progress is being made, and where there is the greatest hope for the future.

SUPERVISION.

Let us now consider what we believe to be the ultimate solution of the problem, without which the best fuel, and the best appliances, will not be effective in reducing smoke, namely, the education and supervision of the men running and firing locomotives.

It must be remembered that on a large railroad system there are thousands of men firing and handling locomotives: First, we have the engineman, who runs the machine and upon whose careful and judicious handling the ease of proper firing largely depends; secondly, we have the fireman, whose skill and interest in properly firing the locomotive must never flag for an instant; third, we have engine-preparers and ashpit men at engine houses, who must understand how to clean old fires and build new ones with a minimum amount of smoke.

With the rapid growth of business and consequent increase in the number of employees, it must be realized that supervision in this sense requires a large force of men, for the reason that owing to the extent of the territory over which any group of locomotives and men run, following up any particular set of men is a very different proposition from that of supervising a very much greater number of men grouped in some one place, as, for instance, in a large power house.

The supervision to be effective involves, first, accurate instruction, and, secondly, repeated personal visitation to see whether this is followed, and third, discipline if the instruction is persistently disregarded, either from inability or indifference, and the correction of abuses, such as the improper preparation of the locomotive for the run.

To show how this supervision is being effected, it must be understood that the organization of the railroad is practically a military one. On each division, the man in charge of the enginemen and firemen, under the superintendent, is the road foreman of engines, who has assistants, each in charge of districts containing a certain number of locomotives and men. In some cases it is the practice for these assistants to have subordinates to instruct in firing, although the tendency is to put in this position, men taken from the ranks of the enginemen, so that their rank will carry authority to instruct both enginemen and firemen. In addition, smoke inspectors, whose entire duty is to report locomotives emitting black smoke, are stationed at various points along the division. The management has prepared definite and uniform instructions, in printed form, which have been placed in the hands of all men responsible for operating, firing and attending to locomotives on the road at the terminals.

Under present-day conditions, more supervision is required than formerly, on account of the rapid increase in railway business, necessitating the employment and promotion of men who have not been through the long course of probation formerly the rule. Furthermore, the importance of educating and developing intelligent supervising officers in order to reach the men, is of late being recognized. At Altoona, there has been installed a testing-plant consisting of a locomotive whose driving wheels rest on suitable supporting wheels placed underneath and taking the place of the usual track, the whole locomotive being firmly connected to a dynamometer that maintains it in position while recording the work performed by the locomotive, so that it is operated in the usual way and produces the usual pull. It is otherwise stationary, subject to careful inspection and test entirely impracticable with the same locomotive running free on the road. By means of this plant, which is entirely devoted to the purpose of securing information, this road is educating its officers interested in the fuel question to its possibilities, so that they may thoroughly understand how to instruct the men to carry out the definite printed instructions.

Furthermore, this road is recognizing the necessity for greater supervision by the appointment of a greater number of supervising officers so that the number of men under the jurisdiction of each will be small enough to admit of constant personal contact.

It must not be forgotten in this connection, that the cost of the supervision mentioned in the foregoing, is a very serious burden on the cost of operation, and while the railroads would not provide such supervision but for the belief that it will yield adequate return, or from realization of the duties which the railroads owe the public, there must be a limit to the amount of money which they can so expend.

As stated before, the cost of fuel is from 8 to 11 per cent of the total operating cost of a railroad, and, therefore, economy in the consumption of fuel is one of the most obvious ways of reducing operating expenses. Fortunately, the methods described in the foregoing for the elimination of smoke from locomotives, are also those which must be followed in order to obtain the maximum economy in locomotive fuel consumption; in other words, the crew making the least smoke is also apt to save the most coal. It follows, therefore, that the railroads have a direct financial interest in the elimination of smoke to the lowest possible limit.

It should be clearly understood that there is no one remedy which can be generally applied. Each situation must be treated as a separate problem, giving attention to such points as the character of the road as to grades, the loading and speed of the trains, the distance which must be run through thickly populated districts, and whether we are considering a terminal or a through station. For instance, the remedy which has so improved the Washington situation will not apply to Baltimore, because the latter is a through station having adverse tunnel grades on each side. The Chicago situation, with Illinois coal, is still another problem. In brief, an intelligent study of the local conditions must be made in each case.

It will be noted that so far, nothing has been said of the possible solution by electrification.

The demand has frequently been made that if not the entire cross country line, the cities or terminals should be electrified. In some cases the same demand has been made where cities are not terminals for any but a small portion of the trains running into them. Such a demand would involve two locomotive terminals, one on each side of the city, electrification of the space within the city limits, a supply of special electric locomotives and the delay of a double stop, to say nothing of the difficulties due to the interruption of such functions as the steam heating of trains. To offset the cost of this, there is no saving whatever in operation; on the contrary, the operating cost is largely increased. If the railroads could stand the burden or cost, it is certain that the public itself would not tolerate unnecessary delays of this kind. Naturally, the roads hesitate to undertake new electrifications, not only on account of the expense, but also because it is wise to learn the lesson of the mistakes of one installation and thus avoid their repetition at another.

While anything of the kind is possible from an unlimited expenditure of money, we do not hesitate to say that the time has not yet come when the enormous outlay of capital for the purpose of the electrification of the railroads would be justified by the returns, and, further, we assert that the capital thus diverted would be far more useful in other directions.

A YEAR'S EXPERIENCE WITH A SUCTION POWER PLANT.

J. C. MILLER, in Power and Engineer, presents the results of a year's operation of a suction gas power plant, stating the fixed charges in a way that will satisfy men who are prone to think of interest, depreciation, etc., as important elements in power cost. The engine under consideration was a single cylinder, horizontal 50 brake-horse-power, regulated on the hit-and-miss principle, and belted to the line-shaft. The gas was drawn from a suction producer, using anthracite pea coal. The plant was of English manufacture, and was well designed and constructed. The producer was equipped with the usual vaporizing apparatus for supplying steam to the blast, and with the usual coke scrubber and expansion box. The cost of the installation of the plant was $3,300. The table below gives the fixed and operating charges:

FIXED CHARGES.	
Interest at 6 per cent	$198.00
Depreciation, repairs, taxes, insurance, 12 per cent	396.00
	$594.00
OPERATING CHARGES.	
Engineer at $2 daily, 300 days	$600.00
67¾ tons coal at $4.50	304.87
Oil and waste	48.00
Scrubber water	12.00
	$964.87
Total yearly charge	$1,558.87
Cost per horse-power-year of 3,000 hours, assuming an average rate of 50 horse-power	$31.17

The repairs of the year were relatively small, consisting of new grate-bars in the producer, new coke in the scrubber, and small repairs to the connecting-rod and ignition equipment. The total cost of the repairs, in fact, were less than $10. In the fixed charges given above, 12 per cent has been allowed for depreciation, repairs, insurance, and taxes, which was more than ample for the year in question. The cooling water was used over and over, and therefore no charge is made for this item. In the item of attendance, the entire salary of the engineer is charged up against the plant, although he had ample time for other work, but little of his time being needed with the producer and engine after the plant was in operation. The coal used came from the Scranton district and cost $4.50 per ton, delivered. The coal consumed averaged 441 pounds per working day, so that it can safely be said that the consumption was only one pound per brake-horse-power.

Mr. Miller sums up by stating his conviction that only hydraulic power can surpass the present showing for economy. The cost as shown corresponds with electric power delivered to the consumers at 1 1/3 cent per kilowatt, much below the lowest commercial rate to consumers using an equal amount of power.

EIFFEL TOWER DEVICE FOR SHOWING HOUR.

THE TIME INDICATOR OF PARIS.

BY OUR PARIS CORRESPONDENT.

SOMEWHAT of a novelty is the incandescent lamp device which is mounted upon the Eiffel Tower at Paris so as to show the hour and minute. The figures show the hour during the night and can be seen for a great distance, as they form an immense electric sign. To avoid trouble from the wind, the lamps are not mounted upon a board, but are placed on a set of horizontal slats, and the latter are hung upon chains at one side of the tower. The device is mounted at the second platform. It is the invention of a Russian engineer, M. Hourko, who occupies a prominent position in the railroad department at St. Petersburg. He applied it in that city with some success, but this is the first time that it has been used on so large a scale. It would appear at first sight that it is easy to operate such an electric sign by clockwork, using a revolving drum to make the contacts, and this would be true if we had a very large clock; but in practice we need to use a small and accurate clock which, of course, could not perform such mechanical work. What is needed therefore is to make the device work from a small clock, and herein lies the originality of the invention, which is carefully worked out after a long experience with the various difficulties. The method is patented in different countries. The inventor kindly furnished the writer with the following explanation of his system:

The mechanism which serves for lighting and cutting off the lamps according to the hour and minute is divided into two distinct parts, one of them being the contact device which is operated by means of the clock, and the second part being a series of relays carrying a heavy current and serving to distribute the current to the lamps so as to form the figures. The idea which is to be carried out is the following: To give a current impulse every minute by the clockwork, this impulse being derived from a battery of a few cells, so as to avoid having a strong current in the delicate clockwork device, which would need heavy contacts and would thus give too large a mass to be moved. By this small current impulse it is desired to operate a relay of a heavy build, with sufficient mass to take care of the large current which goes to the lamps. Thus when we have the hour 8.31, for instance, and the time comes to change the last figure so as to make 8.32 on the illuminated sign, the rotation of the clockwork puts on the contact for figure 2. When this contact is made, a battery current is sent from the clockwork device into the relay device. The relay corresponding to the figure 2 is operated by such current, and the attraction of its armature causes the circuit to be made for the dynamo current which passes into the lamps corresponding to this figure. At the same time the lamp circuit of figure 1 is cut off at the corresponding relay.

In the engraving which shows the clockwork device and also in the diagram 1 will be seen the manner of controlling the battery circuits. One of the shafts of the clockwork is extended in the rear by means of a second shaft coupled to it. This latter shaft passes first through a device containing a set of gear wheels which will be mentioned below, and then extends past this and over the set of mercury troughs *M*, which are placed side by side and have a rectangular form. Each trough corresponds to one of the figures for the unit minutes and seconds, and there are consequently ten of these in the series. Disposed around the shaft is a set of steel pins *P* which project at right angles, and each pin can be made to dip into a corresponding mercury trough. Only one pin can enter the mercury at a time, however. Supposing the pin for minute No. 1 to be vertical, or dipping into the mercury; at the end of the first minute the shaft will have revolved by the corresponding part of the circumference, and pin No. 1 will leave the mercury while pin No. 2 enters it, thus completing the circuit of No. 2, while No. 1 is broken. This arrangement is very effective and at the same time simple, for it enables us to have a series of contacts made by the delicate clockwork without interfering with the action of the latter. It is to be noted that for such a device as the present one the clockwork must run very accurately in order to indicate the exact time, and there must be no friction which would interfere with its movement.

THE LUMINOUS CLOCK OF THE EIFFEL TOWER.

It only remains to secure a similar set of contacts for the second figure (every ten minutes) and the third figure (every hour) or in our example 8.32, the figures 3 and 8. For this purpose the gear device contains a second and a third shaft *B* and *C* which are coupled to the first by gearing. Shaft No. 2 revolves once for six revolutions of No. 1, that is, for the figures from 0 to 5, while shaft No. 3, for the hours, has twelve figures to take care of, and revolves once in each hour, being geared in like manner. Around each of the shafts there are fixed steel pins as on the first shaft, and for these there is a corresponding number of mercury cups for the contacts. Thus it will be seen that during the entire period of twelve hours we are able to close the circuits for the hour, minute and second in the proper succession.

This series of impulses is made to work the second device which contains the relays for throwing on the lamps. As will be noticed in the engraving, it consists of a long table upon which are mounted as many relays as there are contacts mentioned above, each relay corresponding to one figure in the lamp sign. In order to simplify matters, however, there is not a single circuit for each figure, but on the contrary the figures are decomposed into elements which are common to each. This will be observed in the diagram (Fig. 2), where the figure 0 is made up of the elements 1, 2, 3 and 4; figure 2 of elements 1, 7 and 8; figure 3 of elements 9, 10, 11 and 2, and so on. The positive wire of the lamp circuit is common to all the lamps on the signboard, while the negative circuit is used to make the branch circuits to the separate elements (Fig. 3). For element No. 0 we have one wire of the dynamo (+) going direct to the lamps (which are coupled in parallel), and the second wire of the dynamo (—) goes first through the relay and then to the lamps. From the elements 1, 2, 3, 4 of the figure 0 we thus have four wires going to the corresponding relays. In the diagram we observe the dynamo wire + which is common to all elements, while the negative wire passes into a mercury cup *A*. Into four corresponding mercury cups are brought the wires from the four elements, so that should we make a contact between cup *A* and all the others by a common bridge-piece, we thus send current into all the four elements 1, 2, 3 and 4.

In practice this is carried out by the type of relay designed for this purpose by M. Hourko. It has the advantage of being very solid, and there is nothing to get out of order, which is an essential point in the working of a device of this kind, as it must not, of course, require to be looked after. The diagram in elevation and plan (Fig. 4) shows one of the relays for one main contact (*A*) and four lamp elements. It thus has five mercury cups. Above the cups *A*, 1, 2, 3, 4, is a metal casting which carries five carbon pieces, and one carbon dips into each mercury cup. When this contact piece as a whole is brought down, all the carbons dip into the cups, making the connection between all the cups by means of the metal. Thus the main wire *A* is connected to all the lamp elements by a simple movement of the bridge-piece *B*. This movement is carried out by attaching this piece to a lever *L* which works above an electromagnet *C*, using for the purpose an insulating block *D*. The lever is pivoted on the shaft *E* and carries on the rear end the counterweight *F*. Current from the battery circuit enters the electromagnet by a wire coming from the clockwork device (the other pole being grounded). When, therefore, there is a contact made at the clockwork, the armature is attracted and the lever drawn down, making contact at the mercury cups. At the hour 8.30 we have three of the relays drawn down, namely, those corresponding to hour 8 (in the hour set), the figure 3 of the ten-minute set, and the figure for minutes, 0. When the contact is now made for 8.31, the minute relay for the number 1 is thrown on, and number 0 is released. The sign thus shows 8.31, and so on. It will be noted that the relays are disposed in groups according to whether they are used for hours, ten-minute figures or the minutes.

M. Hourko found that in practice it was not desirable to use springs upon the relays in order to give

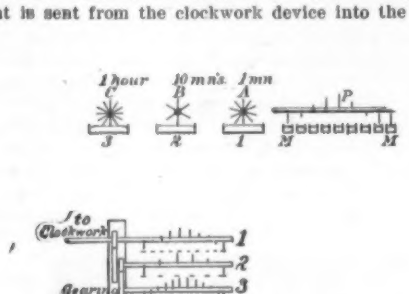


FIG. 1.—THE CLOCKWORK DEVICE.

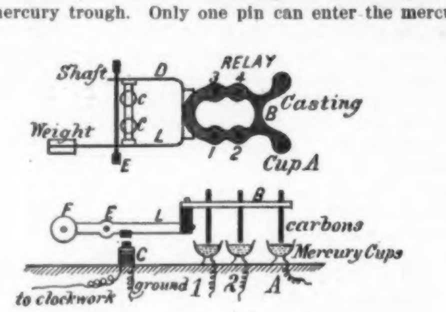


FIG. 4.—ONE OF THE RELAYS.

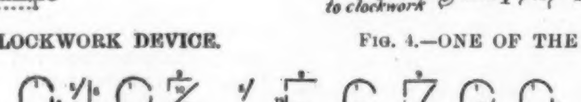


FIG. 2.—DIAGRAM OF THE GROUPS OF CIRCUITS ENTERING INTO THE FORMATION OF EACH NUMBER.

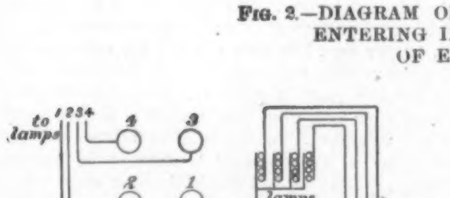


FIG. 3.—DIAGRAM OF LAMP CIRCUITS.

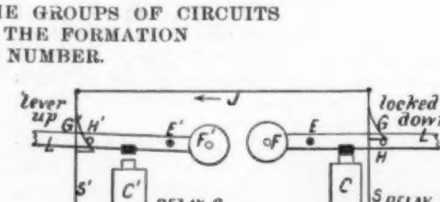


FIG. 5.—CROSS CONNECTION OF RELAYS.

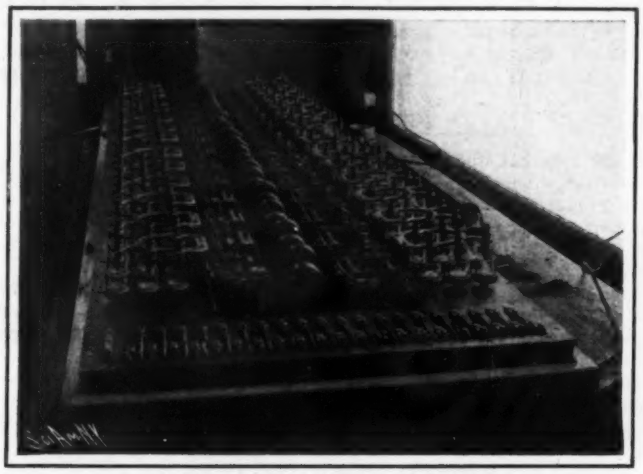
the release of the armature when the current is broken. He therefore uses a counterweight to bring back the lever, combined with a system of catches which lock the levers when they are drawn down. This is clearly seen in the diagram (5) which shows two consecutive relays, 1 and 2. Relay 1, carrying the magnet *C*, lever *L* pivoted at *E*, and the counterweight *F*, is provided with a pin *H* which works with a catch *G* mounted on a spring blade *S* in such manner that when the lever descends it is locked under the cam, having pushed it aside in the descent. On relay 2 there is a similar arrangement. The tops of the two blades are cross connected by a light steel rod *J*. When relay 2 has the current thrown on (No. 1 being now off), its lever descends, pushing the cam *G'* to the left, and this movement is transmitted by the rod *J* to the cam *G*, which moves to the left and releases the pin of its lever. The latter is then brought up by the counterweight.

DEFINITIONS OF ELECTRICAL TERMS.

THE following definitions and classifications are intended to be practically descriptive and not scientifically rigid:

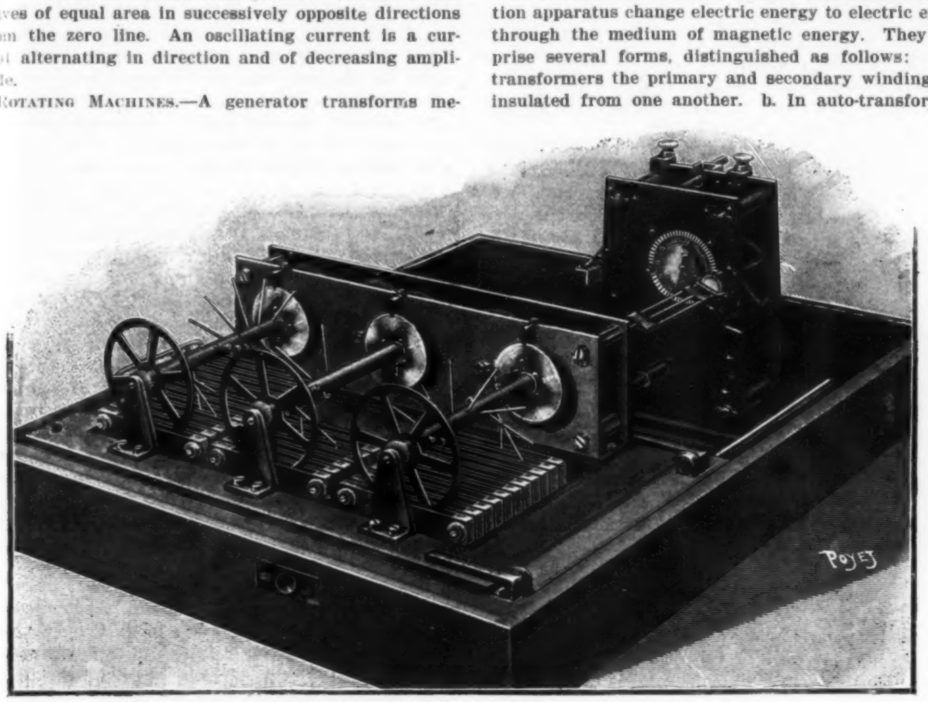
CURRENT.—A direct current is a unidirectional current. A continuous current is a steady or non-pulsating direct current. A pulsating current is a current equivalent to the superposition of an alternating current upon a continuous current. An alternating current is a current which, when plotted, consists of half waves of equal area in successively opposite directions from the zero line. An oscillating current is a current alternating in direction and of decreasing amplitude.

ROTATING MACHINES.—A generator transforms mechanical power into electrical power. A direct-current generator produces a direct current that may or may not be continuous. An alternator or alternating-current generator produces alternating current either single-phase or polyphase. A polyphase generator produces currents differing symmetrically in phase; such as two-phase currents, in which the terminal voltages on the two circuits differ in phase by 90 degrees; or three-phase currents, in which the terminal voltages on the three circuits differ in phase by 120 degrees. A double-current generator produces both direct and alternating currents. A motor transforms electrical into mechanical power. A booster is a machine inserted in series in a circuit to change its voltage. It may be driven by an electric motor (in which case it is termed a motor booster), or otherwise. A motor generator is a transforming device consisting of a motor mechanically connected to one or more generators. A dynamotor is a transforming device combining both motor and generator action in one magnetic field, with two armatures, or with an armature having two separate windings and independent commutators. A converter is a machine employing mechanical rotation in changing electrical energy from one form into another. A converter may belong to either of several types as follows: a. A direct-current converter converts from a direct current to a direct current. b. A synchronous converter (commonly called a rotary converter) converts from an alternating to a direct current, or *vice versa*. c. A motor converter is a combination of an induction motor with a synchronous converter, the secondary of the former feeding the armature of the latter with current at some frequency other than the impressed frequency, i. e., it is a synchronous converter concatenated with an induction motor. d. A frequency converter converts from an alternating-current system of one frequency to an alternating-current system of another frequency, with or without a change in the number of phases or in voltages. e. A rotary phase converter converts from an alternating-current system of one or more phases to an alternating-current system of a different number of phases, but of the same frequency.



END VIEW OF THE RELAYS.

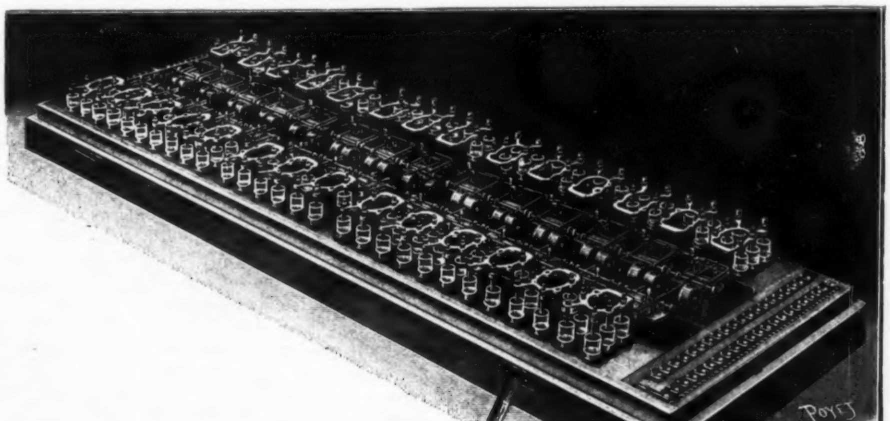
STATIONARY INDUCTION APPARATUS.—Stationary induction apparatus change electric energy to electric energy through the medium of magnetic energy. They comprise several forms, distinguished as follows: a. In transformers the primary and secondary windings are insulated from one another. b. In auto-transformers, also called compensators, a part of the primary winding is used as a secondary winding or conversely. c. In potential regulators a coil is in shunt and a coil is in series with the circuit, so arranged that the ratio of transformers between them is variable at will. They are of the following three classes: (a) Compensator potential regulators in which a number of turns of one of the coils are adjustable. (b) Induction potential regulators in which the relative positions of the primary and secondary coils are adjustable. (c) Magneto potential regulators in which the direction of the magnetic flux with respect to the coils is adjustable. (d) Reactors, or reactance coils, formerly called choking coils, are a form of stationary induction apparatus used to produce reactance or phase displacement.



THE DISTRIBUTING SHAFTS FOR THE RELAY CURRENTS.

MOTORS—SPEED CLASSIFICATION.—Motors may for convenience be classified with reference to their speed characteristics as follows: a. Constant-speed motors, in which the speed is either constant or does not materially vary, such as synchronous motors, induction motors with small slip and ordinary direct-current shunt motors. b. Multispeed motors (two-speed, three-speed, etc.), which can be operated at any one of several distinct speeds, these speeds being practically independent of the load, such as motors with two armature windings. c. Adjustable-speed motors, in which the speed can be varied gradually over a considerable range, but when once adjusted remains practically unaffected by the load, such as shunt motors designed for a considerable range of field variation. d. Varying-speed motors, or motors in which the speed varies with the load, decreasing when the load increases, such as series motors.—Modern Machinery.

That aluminium is not the only active element that can be employed in thermit reactions is the announcement made by Goldschmidt, the discoverer of the thermit process. Silicon does not reduce Cr_2O_3, Mn_2O_3, or Mn_3O_4; MnO_2 is reducible, but a certain amount of Si remains in the metal. The copper oxide reaction goes slowly, and the slag contains small globules of copper silicide containing 10 per cent Si. Calcium reduces in a similar manner metallic oxides, sulphides, etc. The Ca-Si iron reduction is very similar to the Al reduction, but the slag is more easily fusible, and does not solidify so rapidly as the Al_2O_3 slag. The advantages of using mixtures for these reductions are pointed out; a good thermit mixture is made by Ca and Si in the proportion 2:1; this mixture gives 720 kilogramme-calories, while the usual thermit gives about 820 kilogramme-calories. Sixty parts Mg and 40 parts Si form a good mixture. With a mixture of 40 per cent Ca thermit and 60 per cent Al thermit in which Ca:Al::53:47, 850 kilogramme-calories are developed, and the slag produced is particularly fluid, this slag corresponding to $2CaO . 2Al_2O_3$. A mixture of Al-Ca-Si is also used, the best proportion being 20 Al, 47 Ca, and 33 Si, the result of the reaction being a slag Al_2O_3, $3CaO$, $3SiO_2$ which has a melting-point of 1,345 deg. C.



GENERAL PERSPECTIVE VIEW OF THE RELAYS.

NEW DUST PREVENTIVES.*

THE USE OF WATER AND SALT SOLUTIONS.

BY PREVOST HUBBARD.

TEMPORARY binders are materials which have to be applied at more or less frequent intervals in order to suppress dust. Their primary object is to lay the dust only, although they may also tend to preserve the road from wear. No distinct line can be drawn between the permanent and the temporary binders, but in general the latter class may be said to embrace water, salt solutions, the lighter oils and tars, and various emulsions. Some of these materials, however, approach the permanent binders quite closely and can be considered in either class, according to the method employed in their application.

Water is undoubtedly the first material that was ever used for the purpose of laying dust. During hot, dry weather its use has never been satisfactory, owing to its rapid evaporation. Frequent and heavy applications are often required to keep the dust down, and in many localities where the traffic is heavy it is practically impossible to obtain good results by the use of water alone. The cost of frequent sprinklings with water is a considerable item; and when the fact is taken into account that at the end of a season but little permanent benefit has been derived from its use, it will be seen that dust laying by this method is by no means economical. When heavy applications are made the road is apt to be gullied. With certain rock powders, or rock dusts, water will react to form either colloidal or crystalline binding materials, but these binders are not in themselves capable of withstanding the combined attack of ordinary and automobile traffic, and when these conditions have to be met the use of some substance other than water alone is to be preferred.

USE OF SALT SOLUTIONS.

The principal action of water in laying dust consists in the mechanical bond produced by the force of capillarity when two wet surfaces are brought in contact. The action of certain salts may increase the formation of binding material to some extent, but as a rule they are not used primarily for this purpose.

It has long been known that certain salts have so great an affinity for water that they are not capable of retaining moisture for a long time under conditions which would otherwise produce rapid evaporation, but that they are capable of absorbing water from the atmosphere to a great extent. Some of the salts are so hygroscopic that in a humid atmosphere they will often completely dissolve in the water which they have absorbed from the air. Salts of this character are termed deliquescent, and it is to a great extent these hygroscopic and deliquescent salts which have been employed as dust preventives. By their use the roadway is kept in a semi-moist condition for a much longer period than by the application of a corresponding amount of water only, and the number of sprinklings necessary is therefore greatly reduced.

USE OF SEA WATER.

One of these salts, magnesium chloride, occurs to a considerable extent in sea water. The effect of its presence in the cheaper grades of table salt may be seen in the tendency exhibited by the salt to clump in damp weather. This is due to the absorption of water by the small amount of magnesium chloride which remains even after the salt has been purified. On account of the presence of this substance, sea water has been tried in a number of favorably situated localities for the purpose of laying dust. While the number of sprinklings has been somewhat reduced by this means, the results have, as a rule, been far from satisfactory, owing to the presence of an excessive amount of common salt (sodium chloride), which is applied at the same time and which has no hygroscopic properties. In extremely dry weather a hard, salty scale is produced on the road which is very undesirable, and in wet weather the mud contains so much salt that it is injurious to the varnish and ironwork on vehicles. This strong salt mud is also apt to cause soreness around the fetlock of horses.

In the process of manufacturing ordinary salt from sea water a waste product is obtained which is known as "bitter brine," or bittern. This bittern is the mother liquid remaining after most of the sodium chloride has been crystallized out by evaporation. It is rich in magnesium chloride, and therefore more suitable for road use than ordinary sea water. As it is worthless for other purposes, its cost is very low and in certain localities its use might prove economical. Its application for the purpose of laying dust is covered by patent. So far, no very extensive use has been made of this substance, but, as it is apt to contain a considerable amount of inert sodium chloride, the same objections which have been urged against the use of sea water might be applicable here, although to a much less extent.

USE OF CALCIUM CHLORIDE.

Calcium chloride, which is obtained for the most part as a by-product in the manufacture of soda, has been used to a considerable extent as a dust layer. It is more hygroscopic than magnesium chloride and can be obtained at a moderate price in an almost pure state. It is sold either in solution or in a solid, fused, or granular condition. The solid material contains about 25 per cent moisture and 75 per cent calcium chloride, while the solutions run from a saturated condition to various weaker strengths. The ordinary concentrated solution carries about 40 per cent calcium chloride and has a specific gravity of 1.400. Both the solid and solutions are sold as a basis of the actual salt content, and the solid is therefore cheaper when the cost of transportation is taken into account. It can at the present time be purchased at about $16 per ton f. o. b. at points of manufacture.

Calcium chloride has been used to a slight extent in the United States for the purpose of laying dust, and when properly applied has proved successful. The amount of salt and number of applications required to keep down the dust satisfactorily for a season will vary greatly with local conditions, but the exercise of a little judgment makes it possible to obtain good results with a minimum expense. Before considering its advantages and disadvantages, however, its method of application should be taken up.

In most cases it is applied for the first time on the unprepared road. The solution is sprinkled from an ordinary watering cart, so that on an average 0.4 gallon is applied per square yard, although by regulating the spread of the sprinkler to about two-thirds the width of the road the middle receives twice the amount of the sides when the sprinkler passes over the road twice. While the center receives a double application by this means there is a tendency for the whole surface to receive an equal share, owing to the fact that rains tend to carry the dissolved salt to the sides of the road. A 15 or 20 per cent solution is first employed, and at least two of these applications are made in the first week or two in order to impregnate the surface thoroughly with the salt.

The salt thus applied has a tendency to retain moisture for a considerable length of time after an ordinary application of water would have evaporated. On hot, dry days, however, the road does dry out, especially on portions unprotected by shade, and it has been found necessary to feed the salt by ordinary applications of water. The number of sprinklings necessary will, however, be greatly reduced. It is, of course, cheaper to feed the calcium chloride already on the road with water than to apply a fresh solution each time the road becomes dry. In humid weather it is often unnecessary to apply water for days at a time, as the salt absorbs sufficient moisture from the damp night air to keep the road in good condition throughout the succeeding day.

In the course of time much of the calcium chloride is washed out of the road and has to be replaced by fresh material. Single applications of an 8 or 10 per cent solution, applied at intervals varying from two to five weeks apart, according to conditions, are usually sufficient to maintain the proper amount, and these may be made in the same manner as described for the first two. A too rapid drying of the road is an indication that more salt is needed, and a little experience will soon enable the overseer or experimenter to determine just how often and at just what time to make a fresh application. The same is also true with respect to feeding the salt with water.

In regard to ascertaining and regulating the strength of solutions, the most convenient method is to determine its specific gravity by means of a hydrometer. Accurate determinations have been made of the specific gravity of solutions of known percentage composition, and, as hydrometers graduated to direct specific gravity readings can be obtained, the method is a very simple one. A hydrometer graduated from 1 to 1.4 is most suitable for ordinary work, and by comparing the readings with the following table the strength of solution can be immediately ascertained. Also by diluting the salt, or a concentrated solution with water, any desired strength may be obtained if the dilution is stopped at the specific gravity indicated for that particular strength.

SPECIFIC GRAVITY OF SALT SOLUTIONS CONTAINING GIVEN PERCENTAGES OF SALT.

Per cent calcium chloride..........	5	8	10	15	20	30	40
Specific gravity.	1.041	1.068	1.086	1.132	1.181	1.286	1.40[illegible]

A method has lately been devised and patented for diluting and distributing materials miscible with water, which has many advantages as a time and labor saver. As this method is applicable to both salt solutions and emulsions, it may be well to describe it at this point. A watering cart is used similar to the ordinary type, with the exception of a rack attached to the rear, which is capable of holding a nest of five or six galvanized-iron cans, each having a capacity of over 100 gallons. The wagon is capable of holding about 600 gallons. The cart is first loaded with the concentrated material which is to be diluted. It is then driven to the first hydrant along the road. Here a quantity of the material sufficient to give the desired strength when diluted to the capacity of the wagon is drawn off into one of the cans. The wagon then proceeds to the next hydrant, where another lot is likewise unloaded, and so on. If the wagon has previously been loaded with a quantity equal to some multiple of the charges drawn off, a point will at last be reached where a quantity equal to that held by the separate cans remains in the wagon. Enough water is then run in from a hydrant to fill the wagon and the solution thus produced is applied to the road. Upon returning the empty wagon is refilled at each of the hydrants beside which a can of the material has been left, the empty cans being returned to the rack. A siphon arrangement, controlled by the water flowing from the hydrant, serves to lift the preparation into the wagon together with the water, thus producing the desired mixture. By employing a method of this sort many unnecessary trips of the wagon are avoided and the cost of handling is reduced to a minimum.

Where a considerable amount of work is to be done with calcium chloride the concentrated solution may be prepared or stored in large tanks set at an elevation sufficient to allow it to be run into the watering cart by gravity. Some time is required to dissolve the solid material, and, if it is not possible to secure a reservoir, the material should either be dissolved in the watering cart over night or else in the cans which should have been previously distributed at the different hydrants.

The principal advantages of calcium chloride as a dust layer are that it is odorless and clean. When present in sufficient quantity it is undoubtedly a good dust layer if the atmosphere is somewhat humid, or if it is fed occasionally with water in dry weather. While it is true that the formation of mud in wet weather is not lessened, this mud is no more objectionable than that ordinarily encountered, as not enough salt is present to give it the undesirable qualities produced by the application of sea water. In addition, calcium chloride tends to distribute the moisture evenly over the road surface and it can be easily and quickly applied. Its use, like that of any other good dust layer, prolongs the life of a road by retaining the products of wear, and in some cases it may by chemical action increase the cementing value of the rock powder.

On the other hand, it is not essentially a road builder, and at the end of a season's treatment, while the road may be in better condition that at the start, no additional wearing material will be present. Heavy rains are likely to wash most of it from the road, and if a number of showers follow soon after an application much of its value will be lost. Water does not, however, always carry away as much of the salt as might be supposed, owing to the absorbent qualities of many rock powders. Another objection to its use is that in hot, dry weather it requires feeding with water sometimes as often as once a day. In common with all other temporary binders which are applied in solution or emulsion, it can only be employed in localities favored with a convenient water supply.

As a rule, it is slightly more expensive than water alone, but when applied intelligently according to a system similar to that described, the cost of treatment is in some measure reduced. In one case, under severe

* Abstracted from Bulletin 34 of the U. S. Department of Agriculture.

traffic conditions on a macadam road, the cost of laying the dust for one season was reduced from 3 cents per square yard with water alone to 2.7 cents with the use of calcium chloride. Six applications were made—two in June and one each in July, August, September, and October—and on very dry days the road was given one light sprinkling with water. From this treatment the dust was successfully laid throughout the season, while in previous seasons four applications of water a day often proved ineffective. Under certain conditions, therefore, calcium chloride may not only prove to be a good dust layer, but economical as well. And even if the cost is somewhat greater than for the application of water alone, the beneficial effects produced upon the road will, in many cases, more than compensate for this difference.

OTHER SALTS USED IN DUST PREVENTION.

There are a number of other salts, or salt preparations, which have been used to some extent as dust preventives, among which might be mentioned a mixture of nitrate of soda, sodium chloride, and lime. The use of sodium silicate, known as water glass, has also been suggested on account of its tendency to react with some of the mineral constituents of road rocks to form hard, insoluble binding products. An application of a sodium silicate solution followed by one of an aluminium or calcium salt by which insoluble silicates of alumina or lime are formed on the road proper has also been suggested.

"FERRO-BRONZES."

SOME NEW ALLOYS AND THEIR COMPOSITION.

BY ROBERT GRIMSHAW.

Although the word "ferro-bronze" is generally applied by the manufacturers to one particular set of alloys of copper, zinc, and iron, the term is also used in trade for any compound of the three metals named, in which the iron is held in proper alloy and not merely in suspension, as it were.

These alloys, whether rightly or wrongly baptized, run in general about 55 to 62 copper, 45 to 38 zinc, with a small quantity of iron; the exact percentage of the latter varying with the desired uses of the alloy.

Curiously enough, the iron, amounting to only one per cent or less, has more influence on the physical and galvanic properties of the ferro-bronzes than the copper and the zinc.

In contradistinction to many metallurgists, and particularly to the manufacturers of the so-called "ferro-bronzes" now on the market, I claim that the term, as far as the latter half is concerned, is a misnomer; for although etymologically the manufacturers are right, yet from the point of view of use—and Horace says, "Use is the law of language"—bronzes are exclusively copper-tin alloys; and the copper-zinc set are brasses. In this particular the "aluminium-bronze" people are certainly in the wrong; for without either the authority of the etymologists or that of long undisputed use, they apply the word bronze to a group containing neither zinc nor tin.

All sorts of ferro-bronzes can be forged hot; and not only when forged and rolled, but also in cast form, have some of the tensile strength of steel, in which property they are equaled only by the so-called aluminium bronzes, over which, however, they have in some other respects considerable advantages.

The failure of many of the ferro-bronzes which have been put on the market—and of many more which did not get so far—was caused by the fact that in remelting the iron went into slag or gathered in small masses that made all kinds of trouble in turning the castings, and also affected the strength of the articles—and especially of wire—made therefrom.

One set which is being extensively used in Germany has, however, many qualities which distinguish it from its predecessors, sterro-metal, delta-metal, and the host of variations and imitations of the latter. As there are so many varieties thereof, and as early in the introduction of the phosphor-bronzes so many mistakes were made by the purchasers using the wrong alloys, the manufacturers of the new group distinguish the various members thereof by affixes indicating the general predominating qualities—as for instance "Durana manganese bronze," "Durana phosphor bronze," etc. The proportions of zinc and iron vary according to the purpose for which the alloy is to be used.

The groups M and MF are, when in a hot state, easily rolled and forged. Their working temperature ranges between cherry red and almost black; when warm they are highly ductile. The hot-rolled or hot-forged metal is quite hard, but its hardness may be increased by cold rolling or cold hydraulic compressing, without greatly influencing the ductility and malleability.

These two alloys are used where the rusting of steel or the lack of tensile strength and extension of ordinary bronze would be a hindrance—as, for instance, for shafts for circulating pumps, piston rods for various types of pumps for corrosive liquids, tube plates for iron condensers, etc. As far as purely chemical resistance is concerned, they are very resistant to salt, acid, and alkaline solutions. In respect of galvanic action, however, they, like all that contain zinc, are less resistant either than pure copper or than bronzes which contain a large proportion of copper.

The MF alloy, forged and compressed cold, shows an elastic limit of 25 kilogrammes per square millimeter, equal to about 35,560 pounds per square inch; a tensile strength of 48 kilogrammes per square millimeter = 68,276 pounds per square inch, and an elongation of 25 per cent in test pieces of 100 millimeters = 3.94 inches. (In this connection I take the liberty of remarking that in view of the great extension of the metric system, its probable adoption, in the near future, by Great Britain, the United States, and Canada, and the wide circulation of periodical and other technical literature in the English language among non-English-speaking peoples, I give the data both in metric and in British units.)

The MR Durana metal is, when hot, even softer and more ductile than the two just mentioned; it has a handsome reddish-yellow color, which adapts it to use in decorative forging. Sheets thereof can be very nicely embossed.

Alloy C 9 is specially adapted for cartridge shells, as shown by tests in the cartridge factory in Karlsruhe and the government experimental station at Neubabelsberg. This should also be a good material out of which to draw seamless tubes.

Sheets of this alloy showed, when annealed soft, an elastic limit of 12 kilogrammes per square millimeter = say 17,070 pounds per square inch; a breaking stress of 36 kilogrammes per square millimeter = 51,200 pounds per square inch; an elongation of 50 per cent in a length of 100 millimeters = 3.94 inches, and a contraction in cross section of 65 per cent.

Sheets of the same metal, annealed "half soft" had an elastic limit of 32 kilogrammes per square millimeter = 45,500 pounds per square inch, a breaking strength of 46 kilogrammes per square millimeter = 65,425 pounds per square inch, 28 per cent elongation in 100 millimeters, and 60 per cent reduction of cross section.

Hard-rolled sheets of the same C 9 alloy had an elastic limit of 52 kilogrammes per square millimeter = 73,950 pounds per square inch, a tensile strength of 62 kilogrammes per square millimeter = 88,180 pounds per square inch, 9 per cent elongation in 100 millimeters, and 58 per cent reduction of area.

Alloys B and B2 are adapted for yielding handsome non-porous castings of high tensile strength. Among their uses are the manufacture of heavy gear wheels, ships' propellers, pump plungers, and exhaust valves for gas-engines. It is intended to replace phosphor-bronze for these purposes, having, it is claimed, 75 per cent greater strength, while, at the same time, it is very much cheaper.

The official tests of rods cast in sand, of alloy B, showed an elastic limit of 18 kilogrammes per square millimeter = 25,600 pounds per square inch, a tensile strength of 43 kilogrammes per square millimeter = 59,760 pounds per square inch, an elongation of 30 per cent in 100 millimeters, and a reduction in area of 38 per cent.

Alloy B2, also cast in sand in the form of test rods, had an elastic limit of 20 kilogrammes per square millimeter = 28,445 pounds per square inch, a tensile strength of 47 kilogrammes per square millimeter = 66,850 pounds per square inch, an elongation of 22 per cent in 100 millimeters, and a reduction of area of 32 per cent.

The manganese bronzes of this series have the zinc replaced by tin and manganese; hence are really "bronzes." They are used, among other things, for screws, bolts, and nuts in ship construction, where the employment of zinc, by reason of the resultant galvanic action, would be inadmissible. A marked peculiarity of this set is the persistence of tensile strength under high temperatures—the range of unaltered tensile strength extending up to 235 deg. C. = 455 deg. F.—which would point to the use of this alloy for stay-bolts for locomotive fire-boxes.

The official test records of this set are unusually full and interesting, and are given herewith in the form of a table.

The Durana phosphor-bronze should be important for the machine-building industry. This alloy (also really a "bronze") is free from zinc; is not forgeable when hot, but in the cold state can be nicely rolled and drawn into rods and wire. The strength alters very little with increased temperature; remaining, in fact, constant from 0 deg. to 235 deg. C. = 32 deg. to 455 deg. F. This alloy should prove useful for steam-valve spindles, and for screws and nuts that are subjected to heavy strains at high temperatures. The principal uses would probably be in ship, gas-engine, steam-engine, and pump construction.

	Elastic Limit		Tensile Strength		Elongation in 100 millimeters = 3.94 Inches, Per Cent.	Reduction of Area, Per Cent.
	Kilogrammes per Square Millimeter.	Pounds per Square Inch.	Kilogrammes per Square Millimeter.	Pounds per Square Inch.		
Alloy M. B., VII.						
Annealed full soft..	15	21,334	35	49,780	39	78
1/4 hard........ ...	24	34,135	41	58,334	28	76
1/2 hard	32	45,506	45	64,000	21	72
3/4 hard....... ...	44	62,580	51	73,560	15	74
4/4 har	61	86,760	63	89,610	8	70
Alloy M. B., V.						
4/4 hard...............	43	61,160	45	64,000	8	70

A NEW SYSTEM OF WELDING.

On account of the high price of high-speed steel, its use, particularly for heavy tools, has been rather limited in the past. All kinds of devices in the form of tool-holders have been adopted whereby a small tool made of high-speed steel performs the cutting, while the remainder of the tool, or the holder, is of cheaper material. Many attempts have been made to weld high-speed steel onto mild steel, as well as onto high carbon steel, in order that a superior cutting edge may be presented to the work, while the cost of the tool is still kept down to a reasonable figure, the required size and stiffness of the tool being provided for by the body of cheaper material. All attempts to weld high-speed steel onto high carbon steel or machine steel have, however, until quite recently, proved futile. This is apparently due to the different coefficients of expansion of the different steels, high-speed steel having a low coefficient of expansion.

Lately a welding process, however, has been invented by means of which it is possible to weld high-speed steel onto other steels. The operations are very simple. The welding of the two steels is performed by means of a thin film of copper. The copper is placed in the form of a feeder along the line of the joint. The parts to be welded are then surrounded by a reducing compound and are placed in a furnace where the temperature is raised to about 2,200 deg. F. The gas which is formed by the burning of the compound seems to affect the copper in such a way that the latter is reduced to a fluid as thin as spirits of wine, and in this condition it penetrates the molecular surfaces of the two classes of steel and produces actual cohesion and not merely adhesion. In fact, the weld becomes stronger than the remainder of the metal, so that if the two pieces being welded are forced apart, the line of fracture will follow the course of a new break rather than pass through the joint. The weld is so close that in some cases it is hardly possible to find a trace of the copper. A wide field of usefulness is predicted for this process. One application which has already been suggested, and where the process most likely will be most commonly used, is that of welding high-speed steel to carbon or machine steel bodies for the production of high-speed cutting tools at a moderate price.

RADIUM RAYS AND PLANT LIFE PROCESSES.*

SOME INTERESTING DISCOVERIES.

BY PROF C. STUART GAGER, UNIVERSITY OF MISSOURI.

OUR interest in the effects of radium rays on living organisms is enhanced by the discovery that radioactivity is widely distributed in nature. It is probable that all plants and animals are adjusted to a normal degree of radioactivity in their environment, or, in other words, are in a state of *radiotonus*. Prof. J. J. Thomson was the first to discover that air bubbled through Cambridge (England) tap-water became decidedly radioactive, and the subsequent researches of numerous other physicists have taught us that this property belongs to the waters of most deep wells, to mineral waters generally, to freshly fallen rain or snow, to the spray at the foot of waterfalls, to the water of the ocean in certain localities, and quite probably to all spring waters.

After Elster and Geitel found radioactivity a property of the "fango," or mud from the hot springs of Battaglia, in northern Italy, other investigators discovered the same property in mud from various widely separated sources, in lava from volcanoes, in the sediments of springs, the sand of the seashore, and in sedimentary rocks.

The discovery, also made by Elster and Geitel, of the presence of radioactivity in the earth's atmosphere has been abundantly confirmed. Soil-air is more strongly radioactive than air above the surface. Evidence leads to the conclusion that the radioactivity of water, air, mud, rocks, etc., is due to the presence of the emanation of radium and other radioactive substances.

Radioactivity, therefore, must be recognized as a factor of plant environment, and plant physiology and the newer physics join hands. Here, as elsewhere, the boundaries between the different "sciences" break down.

Fig. 1 is from a photograph of a few of the preparations employed in the experiments about to be described. The three marked *R* are sealed glass tubes containing radium bromide. The figures indicate the degree of activity of the preparations in terms of the activity of uranium taken as a unit. Radium bromide of 1,800,000 activity is the purest salt thus far obtained. The lower right-hand tube contains radio-tellurium, which gives off only α rays.

The rod below the tubes is of celluloid, coated on one end with radium bromide of 25,000 activity. The radium coating is overlaid with one of celloidin for purposes of protection.

By means of the rod, not only the three kinds of rays, but the emanation as well, are available. The walls of the sealed glass tubes permit the β and γ rays to pass, but the emanation and the α rays not at all.

Radium coatings, such as those on the rod, were devised by Mr. Hugo Lieber, of New York city, and are a valuable aid in studying the physiological rôle of radium. The experiments of the writer, carried on for over three years at the New York Botanical Garden, were made possible solely through the great liberality of Mr. Lieber, who freely supplied all the standard preparations, several thousand dollars worth in all.

In none of the experiments did the radium itself come in contact with the plant tissues. The results noted were due to the action of the rays alone. When the sealed glass tubes were used, the effect was produced by the β and γ rays, acting together; when the radium coatings were employed, by the combined action of the emanation and the rays, α, β, and γ.

To review the results obtained by other investigators is beyond the scope and purpose of the present article. Koernicke, Dixon and Wighman, A. B. Greene, Guilleminot, and Abbe, not to mention others, have experimented on the action of radium rays on germination and growth, and, to a slight extent, upon other plant processes. There seems to be general agreement among them that the rays exert a retarding or an inhibiting effect, depending upon the activity of the preparation employed and the duration of exposure to the rays.

Germination is easily retarded or inhibited by exposing seeds while dry, or during imbibition of water. In one experiment ten seeds of "Lincoln" oats, after being soaked in water over night, were exposed for eighteen hours to rays from the tube of 10,000 activity, by being placed with their embryo-sides in contact with the tube. Germination was retarded by this treatment. After being exposed for about 50 hours longer to the same preparation (67 hours 35 minutes in all), the seeds, together with ten unexposed, but otherwise similarly treated seeds, were planted in soil in pots. The relative amount of growth in the two cultures at the end of five days after planting is illustrated in Fig. 2, where *R* is the culture exposed to the rays, and *C* the control (unexposed) culture. The growth of the root system was also greatly retarded by this treatment, and the root hairs on seedlings from exposed seeds were much longer than normally.

The effect of duration of exposure on the germination and growth of lupines (*Lupinus albus*) is shown in Fig. 3. The activity of the radium was the same in each case, 1,800,000, the seeds were exposed dry, and the length of exposure, from left to right in the figure, was 72 hours, 50 hours, 26 hours, 0 hours (control). The size of the largest seedling in the pan at the left doubtless indicates that the seed was poorly exposed. There is usually more or less difference in the resistance of individuals, but never as much as that apparently indicated, in the 72-hour culture. This and similar experiments confirm the results of Koernicke and others that the effect varies directly with the duration of exposure.

The relative effect of preparations of different activities is illustrated by the following typical experiment. Three sets, *a*, *b*, and *c*, of six dry seeds of the white lupine were exposed to rays from sealed glass tubes of radium bromide by laying the tubes in contact with the hilum edges of the seeds. Care was taken to have the radium salt distributed evenly along the bottom of the horizontally placed tube. The activities of the preparations were: *a*, 1,800,000; *b*, 1,500,000; *c*, 10,000.

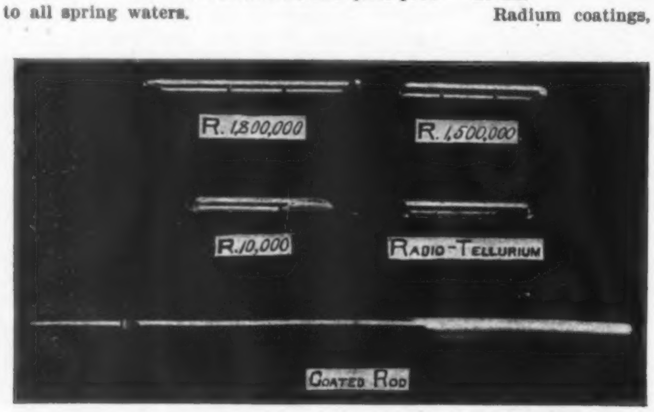


FIG. 1.—SOME OF THE PREPARATIONS EMPLOYED.

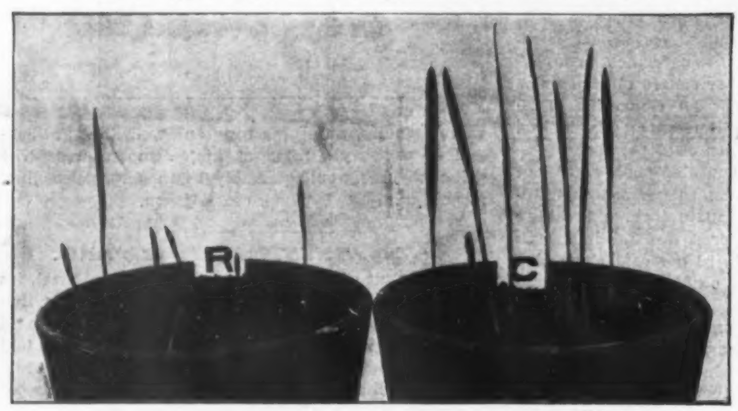


FIG. 2.—SHOWING THE EFFECT ON GERMINATION.

FIG. 3.—EFFECT OF RADIUM ON THE GROWTH OF LUPINES.

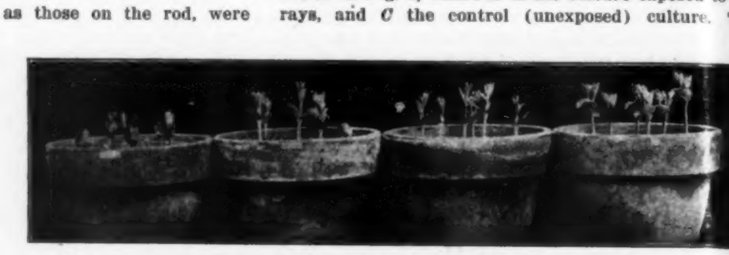


FIG. 4.—RELATIVE EFFECT OF PREPARATIONS OF DIFFERENT ACTIVITIES.

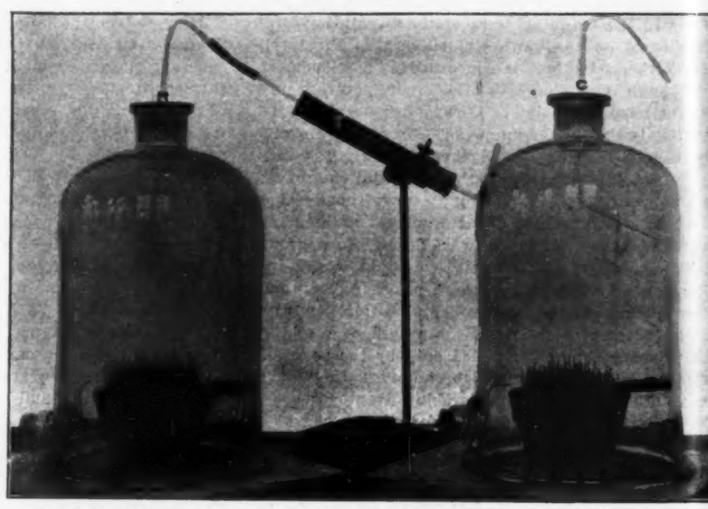


FIG. 5.—LIEBER TUBE.

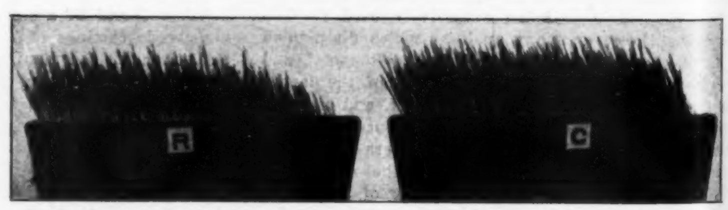


FIG. 6.—EFFECT OF RADIOACTIVE AIR.

* Contributions from the Botanical Department of the University of Missouri. No. 16. Abstracted from Popular Science Monthly.

A fourth set, *d*, served as a control. All exposures were for 91.5 hours. The seeds were then sown in soil in pots, and the comparative amounts of growth in the four cultures are shown in Fig. 4. The activity decreased from left to right. It is clearly demonstrated that the stronger the activity the greater the amount of retardation, under the conditions of the experiment.

An experiment to test the effect of a radioactive atmosphere on germination and growth was facilitated by the preparation by Mr. Lieber of a tube lined with the radium coating devised by him. This tube (*T*, Fig. 5) was connected with the upper tubulure of a glass bell-jar, resting air tight on a ground-glass plate. The lower tubulure was connected with an exhaust, so that air, entering the radium-lined cylinder, carried with it into the bell-jar the radio-active emanation. This air was delivered over pots of growing plants or freshly planted seeds in various ways, one of which is shown in Fig. 5, where the radioactive air passed over the soil-surface from an ordinary dovetail gas burner. The opening to the outlet pipe is under the flower pot. A control apparatus was similarly arranged, with the exception of the omission of the radium preparation. In one experiment, after a six days' exposure of timothy grass seed, sown unsoaked and covered with only an extremely thin layer of soil, germination and growth were shown to be retarded and the amount of retardation was greatest nearest the point of delivery of the radioactive air (Fig. 6). But where germinated seeds of the white lupine, with radicles marked 10 millimeters back from the root-tip, were exposed for twelve hours in the radioactive atmosphere, growth was greater than that of a like number of roots similarly placed in the control jar. In one experiment, for example, the total growth in 24 hours was, for the exposed radicles, 28.66 millimeters, and for the control radicles only 16.08 millimeters.

Thus it is seen that exposure to radium rays, though followed in some cases by a retardation or inhibition of function, may, under certain suitable conditions of exposure and with certain tissues, be followed by an acceleration.

Excitation of function is further illustrated by the following experiment: In a flower pot of soil unsoaked seeds of oat were sown in three concentric circles, distant, respectively, 7 millimeters, 22 millimeters, and 45 millimeters from the center of the pot. Into the soil at the center was inserted the sealed glass tube of radium bromide of 1,500,000 activity. The end containing the radium was about 15 millimeters below the soil surface. A second pot was arranged in a like manner except for the substitution of an empty glass tube for the radium tube. At the end of 106 hours the seedlings from the exposed seeds were much taller than those in the control pot (Fig. 7), the amount of stimulation being greatest in the outer circle of plants and least in the inner circle. At the end of the 106-hour period the radium tube was placed in the control pot and the empty glass tube in the pot *R*. Following this change the seedlings in *CR* grew faster than those in *R*, now serving as a control. Thus it was possible to accelerate the growth of the seedlings in either pot at will by transferring the radium tube from one culture to the other.

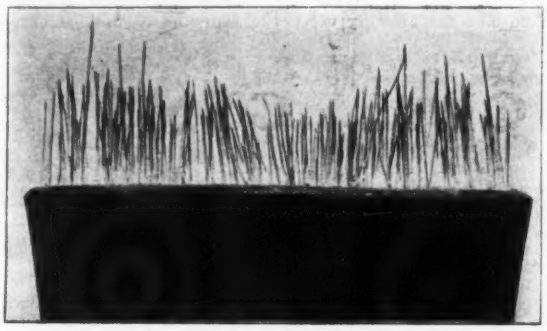


FIG. 9.—THE RADIOACTIVE EFFECT OF THE GAS MANTLE.

The fact that incandescent gas mantles contain a large percentage of thorium, a radioactive substance, suggested the following experiment. On the surface of soil in a pot was sown a row of timothy grass seed, and over this row and at right angles to it was suspended a fresh, unburned mantle at a distance of three to four millimeters above the seeds (Fig. 8). Germination and subsequent growth were both retarded by the rays from the mantle, and Fig. 9 shows the appearance of the culture seven days after the experiment was started.

The influence of radium rays on photosynthesis was tested in several ways. For example: A nasturtium (*Tropæolum*) plant was placed in sunlight after having been in darkness for 18 hours. Under one of the leaves, and lightly in contact with it, was placed a Lieber's coated rod of undetermined (probably 25,000) activity. After twenty-four hours the leaf was dechlorophylized and stained with iodine to test the presence of starch. Starch was almost entirely wanting in the part of the leaf that was directly over the radium-coated rod, but was present in other portions of the leaf. The result was recorded by exposing the leaf to sunlight in contact with the velox paper in a printing frame. The region lacking starch, being more translucent, gave the darkest image on the velox paper (Fig. 10).

It was found possible to increase the rate of respiration of germinating seeds by means of the rays, and alcoholic fermentation was also accelerated by suitable exposure, as follows: Five fermentation tubes were filled with equal quantities of a mixture of 2 grammes of a compressed yeast cake in 250 cubic centimeters of a 5 per cent solution of cane-sugar. Into four of the fermentation tubes were placed sealed glass tubes as follows: $RaBr_2$ 1,500,000 ×; 10,000 ×; 7,000 ×; radio-tellurium. The fifth served as a control. At the end of about three and one-half hours the cultures were photographed (Fig. 11). It is clearly shown in the figure that the rate of alcoholic fermentation, measured by the evolution of gas, was accelerated by the rays; most by the preparation of 1,500,000 activity, least by that of 7,000 activity, and to an immediate degree by the other preparations.

Various attempts have been made to detect a tropistic response, or curvature of a growing organ toward or from a radioactive source. The phosphorescent light of radium has not been found intense enough to call forth phototropic curvatures, and the existence of a true radiotropism is yet to be demonstrated. Koernicke found that seedlings grown from exposed seeds were still sensitive to gravity and unilateral illumination, and the experiments of the writer confirm this result. Under certain conditions of exposure of corn grains, however, the seedlings failed to respond to gravity, and grew horizontally, close to the soil surface. Thus, in one experiment, the grains were exposed for twenty-seven hours to rays from radium bromide of 1,800,000 activity, and all of them showed this tendency to a greater or less degree (Fig. 12, pot 27). Whether geotropic sensibility was de-

FIG. 7.—EXCITATION OF FUNCTION.

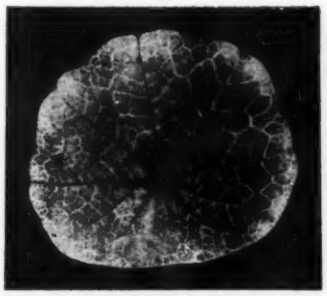


FIG. 10.—PHOTOSYNTHETIC EFFECT.

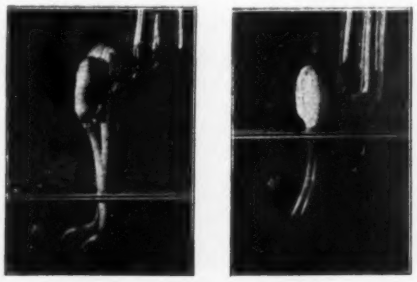


FIG. 13.—EFFECT OF RADIUM ON GROWING ORGANISMS.

FIG. 11.—INCREASING THE RATE OF ALCOHOLIC FERMENTATION.

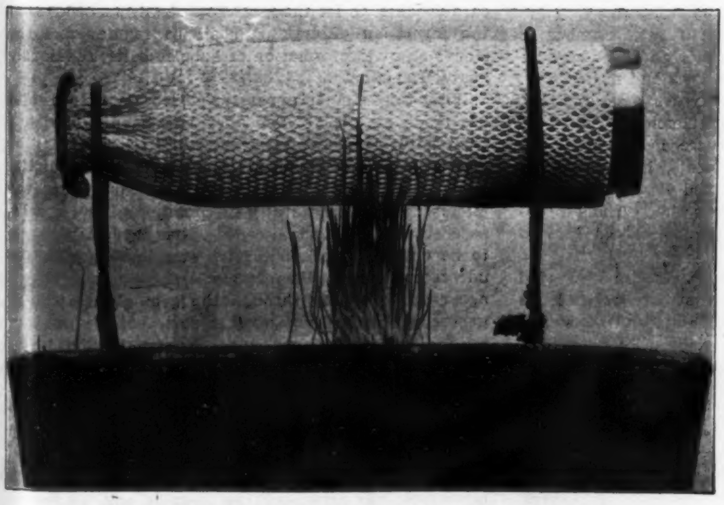


FIG. 8.—AN INCANDESCENT GAS MANTLE AS A RETARDER.

FIG. 12.—EXPERIMENT TO DISCOVER EFFECT OF RADIUM ON DIRECTION OF GROWTH.

stroyed by the exposure is difficult to say, for histological examination showed the tissues to be so abnormal that it is possible the plants could not have stood erect even if they had been able to detect the stimulus of gravity.

All attempts to obtain a curvature of growing organs or plants toward or from a radium tube or radium-coated rod proved unsuccessful, but when a sealed glass tube of radium bromide is suspended horizontally in tap-water, or in nutrient solution, in which radicles of white lupine seedlings are growing vertically, the tips of the roots may be made to curve toward the radium. Such a result is illustrated in Fig. 13. In this experiment the radium tube was originally about 5 millimeters distant from the root-tips. Whether this result was due to the direct influence of the rays, or to some undetermined condition established by them in the liquid can not yet be decided.

The above experiments were all confirmed by repetitions, and clearly indicate that radium rays act as a stimulus to the various physiological processes of plants. If the strength of the radium, the duration of exposure, and other conditions are suitable, the response is an excitation of function, but if the method of treatment is otherwise, the radium too strong, the exposure too prolonged, the result is a retardation, or complete inhibition of function, or the death of the plant. There are not only differences in sensitiveness between individuals, but also between different species and different tissues. As in the case of animals, embryonic and younger tissues are more sensitive than those that are older and more mature.

ARTIFICIAL GEMS PAST AND PRESENT.

IMITATING NATURE IN THE LABORATORY.

BY EMIL FREUND.

Pliny mentions the imitation of jewels by glass fluxes, and it is sufficiently proved that the ancients were far advanced in this art. Egyptian mummies are provided with glass buttons of green and blue color. During the Roman Empire the use of colored glass was very general. Antique cameos have been found carved in varicolored glass to represent the onyx. Colored glass was also cemented with real onyx, but the combination was never so perfect as to defy detection by the artist and jeweler.

Before dealing with the production of imitation and artificial precious stones, another distinction in terms may be made for convenience, a distinction between the words "imitation" and "artificial." To many this may appear unnecessary, the two terms being more or less synonymous. With the advance of scientific research the chemist can now make in the laboratory not merely glass imitations, but real stones artificially, which are identical in composition with those found in nature. Their artificial production is quite modern, carrying us back only a generation or two. Imitation stones, however, were known in the Middle Ages, if not earlier. They were certainly known to the alchemists; for St. Thomas Aquinas mentions imitation jacinth, sapphire, emerald, topaz, and ruby. In the middle of the seventeenth century pastes were not manufactured according to a different formula for each stone, as had formerly been the case, but according to one general formula, much the same as that in use at the present time. Artificial precious stones are again classified as (1) reconstructed stones, (2) manufactured stones, properly speaking, whether they are made scientifically or synthetically.

The first precious stone which artificially reproduced not only the appearance but also the characteristics of a natural stone was lapis lazuli, the sapphire of the ancients, which is not to be confounded with the sapphire of our modern jewelers. This untransparent stone of a magnificent azure blue color, was most highly prized by the ancient Hindoos, Assyrians, Persians, Jews, Egyptians, Greeks, etc., and this irrefragably refutes the erroneous theory of some archaeologists that the ancients were unable to distinguish the blue color.

PASTES.

The basis of paste imitations is a fine, pure, and white glass composition, called "strass," after its inventor, Strass of Strassburg, in the seventeenth century, who first conceived the importance of imitating the real gems as respects their hardness, specific gravity, and refraction of light. He accomplished the task so admirably that in many instances, either all three, or one or the other of his objects, were attained. The strass is composed of silicon, potash, borax, red lead, and sometimes arsenic.

For imitating colored gems, various colored ingredients are employed. To obtain that intensity of color approaching nearest to the original gem experience alone can guide the manufacturer. In order to imitate the uniform and intense colors, the strass coloring ingredients must be finely divided or powdered, and very intimately mixed. The mass is then to be exposed to a very great heat, and in that state left for nearly thirty hours, so that the cooling may be gradual. M. Feil of Paris was one of the first men to produce a good quality of strass, and as a result imitations are now made so well that their detection is exceedingly difficult.

DOUBLETS.

Imitating real gems by "doubling" takes place when quartz cut and polished is cemented by means of gum mastic to colored paste, whereby the whole stone assumes the color of the lower paste. When a real gem is employed instead of quartz (the surface and the quartz or paste being cemented below) the process is called "half doubling." This adulteration is carried on to a very great extent in the East Indies, where any thin gem is joined to a paste of corresponding color.

The concave doubling is effected by excavating the inside of a quartz or paste. This cavity being filled by a colored fluid, and the other part afterward cemented on it, will, when well executed, present so uniform a color that it is difficult even for a judge to detect the deception. The surest method of detection is to put the specimen in question in hot water or alcohol, so that the gum mastic will be dissolved. When set, the only way of discovering the adulteration is to put it reversely on the nail of the thumb, when the false refraction of light or the rainbow colors will surely reveal its identity.

BURNING.

This mode of adulterating the real gems by coloring cut and polished quartz specimens and throwing them into a solution of permanent pigments, such as indigo, cochineal, or ammoniacal copper, the small cavities produced by the heat will absorb the fluids. The topaz is burnt by itself, with or without the absorption of a pigment, as also spinel and quartz. Chalcedony is, however, frequently burnt to imitate onyx, and to engrave thereon cameos and intaglios. It may be remarked, however, that since the introduction of colored pastes very few adulterations of this kind are practised and we see such doublets and burnt stones but rarely.

ARTIFICIAL GEMS.

Artificial gems are at present of considerable interest and furnish an example of the strides made by modern chemistry. In 1886 there appeared in the Paris market certain stones which had been offered for sale by a Geneva house as rubies from a new locality; subsequently, it was said that they were obtained by the fusion of a large number of small rubies, worth at most but a few dollars a carat, into one gem worth many times that amount. An examination proved that they were not the product of a fusion, which would have resulted in the formation of a substance lower in its specific gravity and softer than a ruby. They were artificial stones and had been formed by heat, not from rubies, but evidently by passing an aluminate of lead in connection with silica into a siliceous crucible, the silica uniting with the lead to form a lead silicate and liberating the aluminate, which crystallized in the form of corundum. The difference between these stones and the true ruby was very apparent, owing to the presence of a large number of spherical bubbles, some pear-shaped, and a stringy internal structure, showing how bubbles had moved. Mr. Ebelman, at Sèvres, over sixty years ago, and Mr. Fremy of Paris, after years experimenting has with the assistance of M. Verneuil succeeded in obtaining large numbers of beautiful crystals, but only after many experiments, and conditioned largely upon the heat, which regulates chemical action. Though the color is excellent, the crystals do not exceed 1/25 to 1/50 of an inch in diameter.

Several decades ago the chemist Gaudin succeeded in obtaining small ruby pellets from pure argillaceous earth, precipitated from dissolved alum and moistened with chromate of potash. The color of these rubies, according to the quantity of chromate which they contained was either that of a rose or bordering purple. The pellets were so hard that they easily cut glass, garnets, and topazes, but they were not crystals and their transparency was by no means perfect. Similar experiments were made by the chemists De Bray, Sainte Claire Deville, Caren Senarmont, Ebelman, and others.

"Reconstructed" rubies are obtained by melting together or fusing small rubies of inferior quality with quartz of the same hardness and specific gravity. They came to America in 1886 and were sold as high as \$80, \$100, to \$150 per carat. Others again were sold for \$20, \$10, etc. Again others could not be used as gems and were even not good enough for mechanical purposes. The inventor of the reconstructed rubies was a Catholic priest who lived in seclusion near Geneva. He furnished this reconstruction rough to a lapidary firm of that city, who introduced the same to the trade. With his death the formula, which was a secret, was lost. Never since have better rubies been produced. A few can still be found in the hands of gem lovers.

In 1889 a well-known American firm imported an artificial ruby called a "scientific ruby." This ruby was built up or fused together out of small inferior rubies and later split and polished. These stones were all cut in the old Indian cut and after they came to New York they were assorted according to their quality and then recut in the modern style. These scientific rubies were examined by the Columbia School of Mines, and the test showed that they were fused from natural rubies. Only their hardness showed that they were harder than the genuine stone, while the specific gravity, the optical and chemical properties were those of the natural ruby. These rubies were sold from \$60 to \$150 per carat, none less than \$60.

These stones were all of fine color and good quality. Reconstructed rubies, on the other hand, are sometimes brownish and resemble garnets. It was rather difficult for an expert to recognize them at first glance. The stones had the same inclusions as the natural ruby. Through competition these rubies were sold cheaply and now none as good are made. These scientific rubies were a puzzle to the lapidaries. It was in their favor that they were crystallized, while this was not the case with the reconstructed. The rubies sold at present as "reconstructed" or "scientific" are not what they pretend to be. They are all artificial rubies and ought to be called so.

It is reported that as a result of numerous experiments certain French chemists have at length succeeded in discovering a new method of producing artificial rubies, which is more practical and considerably cheaper than the ordinary process. The "machine" constructed for the manufacture of rubies is provided with a blowpipe similar to a glass blower's pipe and a heating pipe. In the latter are sifted finely-pulverized alumina and chromium oxides alternately to form a deposit in strata and in the shape of a conical sugar-loaf. This formation makes gradual heating possible. The mass assumes a spherical form, and on hardening the crystalline character of the ruby appears. Great care is taken to let the mass cool slowly in order that the formation of crystals shall be regular and the stones clear, the formation of bubbles being sedulously guarded against.

With this simple apparatus three or four rubies are made at a time, and they can be distinguished from natural mechanically cut rubies only by skilled experts. The artificial ruby can readily be distinguished from the natural by examination under the microscope. The natural gem contains minute cracks, as seen with the microscope. Even though it seems to be entirely flawless, careful examination with the microscope of 100 diameters will show minute cleavage cracks running through the gem. The artificial gem contains nothing of this sort, but shows very minute bubbles or gas holes. So far as the luster and hardness are concerned, the artificial stone is exactly like the natural, and no one could tell the difference, except by this microscopic test.

Small artificial stones are made after an invention of Boettger of the same material as the genuine, chiefly alumina. The hydrate of alumina is precipitated from the solution of an alumina salt, by means of an alkali; then well washed and mixed with nickel salt, and rolled into small sticks about the thickness of a finger. Any cracks formed during drying must be filled with the same material. When dry, the end of such a stick is held in the intensely hot flame of an oxy-hydrogen blowpipe, whereupon globules are melted off, among which some will be so hard as not only to scratch glass, but even quartz, topaz, and granite. These are then cut and polished like gems. When nickel salts are used the emerald is obtained. For rubies, chromate of potash is used. They may be

easily distinguished from the originals by their want of that perfect transparency which remains the distinguishing characteristic of the natural precious stones.

By another chemical reaction, namely, the use of fluoride to set free the aluminate, fine but small crystals were obtained, and these were finally increased in size by a modification of the process known as "nursing," in which a crystal is kept in the mother liquid at an appropriate temperature until it grows as large as desired. This requires the elevated temperatures (1,500 to 1,800 deg. C.) possible only in recent years. The process, which succeeded only after many failures, is now carried on as follows:

The small ruby to be "nursed" is placed on a turning plate, where, by means of an oxy-hydrogen blowpipe, it is raised to a temperature of about 1,800 deg. Then, with a pair of pincers, there are added to it successively tiny grains of ruby. If this work is carried on uninterruptedly without losing sight of the crystal, with the dexterous movement of the hand that is quickly acquired by women, it is easy to get fine crystals, all of whose parts, though not homogeneous in origin, are melted together and recrystallized into a single form, which may be cut like a natural crystal. One of the difficulties of the work is that the crystals often break while cooling. The quality of these rubies is very similar to that of the natural stones; they can scarcely be distinguished except under a lens by the presence of air bubbles, but when they are recognized, as the purchase of a precious stone is after all a question of fashion, their value is at least ten times less than that of natural rubies, whose price has also been influenced by this vulgarization of a substance that was formerly sought for its rarity even more than for its intrinsic value. It must be understood that an artificial ruby is not a real ruby, since it is not the natural gem, which alone has hitherto borne the name of ruby in commerce, and since its qualities in jewelry are still inferior, but it is also not a false ruby, since chemically, physically, mineralogically, optically, in all its theoretic characteristics, the synthetic ruby is similar to the natural ruby. The synthesis is not a falsification; it is the reproduction by man of the work of nature.

The synthetic gems introduced and made in the laboratory and lapidary shops of the "Deutsche Edelstein Gesellschaft" are made according to the formula of Prof. Mielhe. The formula is a secret. So far it is known only that the production of the sapphire was not a success, while the ruby and especially the spinel were successful. The synthetic ruby is chemically built up at a certain temperature until it crystallizes. The crystals are often very large. On this same method "alexandrites" are made. According to Prof. Mielhe, the synthetic stone is not a natural stone, although it looks like a natural stone; experts at first sight cannot recognize the natural from the synthetic. Careful examination is necessary. The crystallization of alumina, which yields, according to circumstances, corundum, ruby, or sapphire, has been accomplished for many years (since 1837) and in many different ways, but it is only since the work of Frémy (with the collaboration of Feil and Verneuil, 1877-1890) that the operation has assumed industrial importance.

The process employed at first by Frémy and Feil consisted in forming a fusible aluminate (generally aluminate of lead) which was then decomposed by a silicious substance, setting free the alumina in crystalline form. The red coloration, which characterizes the ruby, was obtained by adding 2 to 3 per cent of bichromate of potash. By this process rubies were obtained that were often very large, but always friable and consequently of no use.

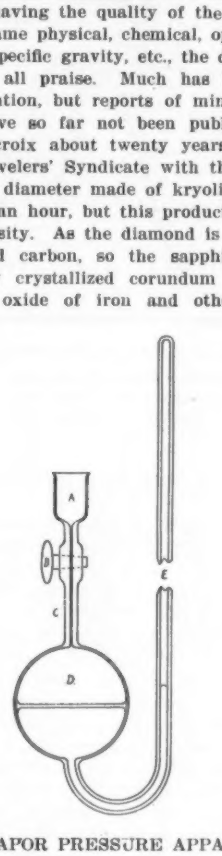
Artificial crystallization of alumina was accomplished several years ago. The color in the resulting mineral was superb, but the individual crystals were so minute that a microscope was needed to distinguish their angles. They were united by their bases to a crust of amorphous alumina, and sparkled like tiny red stars whenever the light played upon them. The natural ruby doubtless took years, and very likely centuries, to form. The chemical ruby, which is precisely the same as the natural ruby, is made in a few weeks. It is almost pure alumina, the red color being due to a fraction of one per cent iron. The sapphire is the same as the ruby, except for its coloring matter. It has a wide range of color, varying from yellow, purple, pink, and gray to white. Corundum is the common variety of alumina, and is much used in the arts. The ruby is the most costly of all gems, a stone of deep color far outranking the diamond in value. Hence the discovery that it can be made in a laboratory is disquieting to dealers in precious stones. The artificial ruby, to use an incorrect term, is as durable and beautiful as the best product of the Burma mines, and it is only the magnifier that shows the little bubbles.

EMERAUDE SOUDÉE.

There has been sold in Paris for some years, and from Paris distributed in the markets of the world, a stone which is called "*emeraude soudée*." The color of this stone is yellowish or bluish green, its specific gravity 2.70 to 2.71. It is as hard as quartz. As quartz can be scratched with a good English steel point, so can the *emeraude soudée* be scratched. A genuine emerald cannot be scratched at all by steel. As soon as this *emeraude soudée* comes to a red heat in an alcohol flame, a light brown material appears on the girdle. If this stone is split, the cleavage surfaces of the upper and under parts are also colorless. The green layer that lies between these two parts is no emerald at all, but a green chromo oxide containing fluid substance, which at a high temperature very strongly connects the two parts. As the quartz is very porous, the coloring substance percolates through and can be seen on the cleavage surfaces. The *emeraude soudée* is nothing more than quartz with a chromo oxide coloring substance which stands cooking in alcohol and heating. It has only the name and color of the emerald.

ARTIFICIAL SAPPHIRES.

Mr. Paris of the Pasteur Institute and his teacher, Mr. Lacroix, of the French Academy of Sciences, are said to have been successful in making artificial sapphires. Until now all the investigations and experiments of chemists proved fruitless. Should the French scientists have succeeded in making an artificial sapphire having the quality of the natural sapphire and the same physical, chemical, optical properties, hardness, specific gravity, etc., the discovery certainly deserves all praise. Much has been written about this invention, but reports of mineralogists or gem experts have so far not been published. It is known that Lacroix about twenty years ago scared the Parisian Jewelers' Syndicate with the ruby crystals of 1/5 inch diameter made of kryolith, which he had heated for an hour, but this product was only a laboratory curiosity. As the diamond is nothing else than crystallized carbon, so the sapphire, like the ruby, is merely crystallized corundum mixed with chromium and oxide of iron and other pigments.



A SIMPLE VAPOR PRESSURE APPARATUS.

After the chemical composition of natural precious stones was known, chemists attempted to reproduce it in the laboratory. Mr. Paris's method (according to the SCIENTIFIC AMERICAN, December 17th, 1908) of making artificial sapphires consists in introducing foreign elements into the combination. Alumina and oxide of cobalt are theoretically all that is necessary to form the sapphire. The latter serves to produce the yellow color and is a small fraction of the whole amount. Mr. Paris conceived the idea of adding 2 per cent of lime and magnesia. The whole mixture was melted at the usual high temperature. The effect of this combination is surprising. Formerly the melted alumina crystallized upon cooling and eliminated the coloring matter, but in the present case this crystallization does not take place. The mass becomes colored and remains permanently in this state. At the moment of the highest temperature the lime and magnesia are driven off and the aluminate, colored by oxide of cobalt, remains. This substance is therefore the artificial sapphire, and it is chemically identical with the stone found in nature.

An artificial, reconstructed, scientific, or synthetic precious stone may be as fine as a natural stone. But microscopic examination always reveals internal regular inclusions, clouds, etc., while in the natural stone these formations are irregular.

Our knowledge of the subject has been added to by the investigations of such men as Gustave Rose, Heintz, Manross, Dumbree, Senarmont, Hautefeuille, Berthier, Forchhammer, Wöhler, Becquerel, Wibel, Moissan, Ebelman, Franbe, Crookes, Noble, Fouque, Sorbey, Levy, Mielhe, Goldschmidt. A few American chemists have also contributed (Fischer) a little to the practical solution of the problem.

A SIMPLE VAPOR PRESSURE APPARATUS.*

By E. J. RENDTORFF.

A HIGHLY desirable experiment in the physical laboratory is the determination of the vapor pressure of various liquids at different temperatures. This experiment is not given in the numerous secondary school manuals and consequently no satisfactory apparatus for this purpose is sold by our various supply houses. In Prof. Millikan's book, "Mechanics, Molecular Physics and Heat," a simple form of apparatus for this determination is described, but it has the disadvantage of being non-transportable when filled.

The accompanying illustration presents a similar type of apparatus that is transportable and can readily be filled with any liquid whose vapor pressure is to be studied. To a bulb *D*, about 6 centimeters in diameter, is attached a graduated tube *E* some 85 centimeters long and 4 millimeters internal diameter. Above the bulb is attached a stopcock *B* and a small cup *A*.

The tube *C*, of small internal diameter, is sufficiently long to prevent the stopcock from coming in contact with the water in which the bulb is immersed.

To fill the apparatus open the stopcock, attach a Geryk air pump and exhaust the bulb thoroughly. Close the stopcock and fill the cup, *A*, with clean mercury. Allow nearly all of this to enter the bulb. Refill the cup and allow the mercury to run into the bulb until the latter is from one-third to one-half full. Incline the apparatus, allowing the mercury to completely fill the long tube. On erecting the apparatus the mercury in *E* will stand at the same, or a slightly lower level (due to capillarity), than in the bulb.

Now allow a few cubic centimeters of the liquid, whose vapor pressure is desired, to enter the bulb. Totally immerse the bulb in a pail of water, stir constantly, and take the vapor pressure for every increment of 5 deg. C. Plot the curve.

The water in the bulb can now be removed by evaporation under diminished pressure and other liquids introduced.

When the barometer pressure is low, and the boiling point of water consequently below 100 deg. C., a handful of some salt can be dissolved in the water, to increase the temperature of ebullition. In case the glass tube is not graduated the vapor pressure readings can be taken with an ordinary meter stick. Where previous determinations had been made of the relation between boiling point and pressure it will at once become apparent that a liquid boils when its vapor pressure equals the external atmospheric pressure.

When the apparatus was first designed it was feared that leakage of air at the stopcock, due to the expansion of the glass, might seriously interfere with the results of the experiment, but after a test of several weeks no appreciable leakage could be detected. The stopcock was, of course, first coated with a good grade of vacuum wax.

On opening the stopcock a regular barometer results, which can be used during that part of the year when heat is not being studied in the laboratory.

* School Science and Mathematics.

In a paper presented to the Académie des Sciences, Messrs. Courmont and Nogier describe their researches upon the sterilization of water by the mercury vapor lamp with quartz tube. Küch in 1905 showed that when the glass tube is replaced by a quartz tube, the light is very rich in ultra-violet rays. Kromayer constructed a lamp in quartz on this principle for therapeutic purposes. With this lamp there is a great intensity in the ultra-violet rays. Th. Nogier and Thevenot (1908) made researches on destruction of bacteria by the Kromayer lamp, using cultures upon gelose. The present authors use the lamp on the same principle of sterilizing water. They employed a lamp of 4 amperes and 135 volts and found that the microbes were destroyed in water at 12 inches distance from the lamp. They then had made a metallic tank of 115 liters (30.4 gallons) having 24 inches diameter, and suspended a quartz lamp of 12 inches length in the center of the tank, using a current of 9 amperes and 135 volts. The sides of the tank are thus at 12 inches from the lamp. Numerous experiments showed that the water was completely sterilized (ordinary microbes of water, coli, Eberth bacillus) and at the end of one or two minutes, even when the water is very impure naturally or artificially. One minute action is nearly always enough. In these tests the water must be quite clear. It is supposed that the size of the present tank does not indicate the limit of output with such a lamp, but that it can sterilize a large amount of water. It is probable that such a method can be used in practice for sterilizing drinking water, which, however, must be clear. We place lamps either in a tank or in the inlet piping at the proper distance, so that the water is acted upon for one or two minutes. The lamps will last indefinitely, and the operation can be controlled by simply observing the light.

SUB-AQUEOUS PHOTOGRAPHY.—II.*

PHOTOGRAPHING AQUATIC ANIMALS IN THEIR NATURAL ENVIRONMENT.

BY JACOB REIGHARD, PROFESSOR OF ZOOLOGY, UNIVERSITY OF MICHIGAN.

Continued from Supplement No. 1737, page 255.

PREVIOUS ATTEMPTS TO PHOTOGRAPH SUBMERGED OBJECTS BY MEANS OF A SUBMERGED CAMERA.

Photography by means of a submerged camera was first attempted by Dr. L. Boutan, of Paris, at the seaside laboratory of Roscoff, in 1893. His work was continued through the seasons of 1895, 1896, 1897, and 1898, and the results have been published in four communications (Boutan, 1893, 1898, 1898a, 1900). Boutan's apparatus was used wholly in the sea, and he has given to his method the title *"la photographie sous-marine."* I shall use instead the broader term subaquatic photography, as indicating the wider application of the method to both fresh and salt water.

Boutan made use of three forms of apparatus, which may be designated as his first (1893), second (1896), and third (1898) apparatus. Each of these will be briefly considered.

He was led to take up subaquatic photography by his study of the development of the mollusk *Haliotis*. Finding it impossible to rear the larvæ of this form in aquaria and failing to collect them in their natural environment by the usual methods, he decided to search for them by descending in a diver's suit. He was struck by the beauty and interest of the submarine landscape and of its inhabitants. He found it impossible to bring his experience vividly before others by mere verbal description and equally impossible, while inclosed in the cumbersome garments of the diver, to make drawings, or even sketches, of what he saw. He was thus led to try photography. He appears to have made no attempt to operate with a camera placed above the water, for, as he says, "when the surface of the liquid is absolutely quiet the rays of light coming from submerged objects enter the objective placed in air at the same time with the rays reflected by this mirroring surface and that suffices to destroy all clearness in the images." He objected to this method for the further reason that it could result in giving only a plan or bird's-eye view similar to that which is obtained when landscapes are photographed from the elevated car of a balloon. He therefore decided to construct an apparatus that could be used under water. It seemed to him possible to proceed on either one of two principles: (1) "To have made an objective that could be immersed directly in water." (2) "To have built a tight box in the interior of which the ordinary objective could be placed protected from salt water." In his first and third forms of apparatus Boutan made use of the second principle. In his second attempt he made use, without success, of an objective immersed in water.

Boutan's First Apparatus (1893).—In this apparatus Boutan made use of a detective camera of fixed focus, an instrument intended to make instantaneous pictures at all distances beyond 3 or 4 meters without focusing. This camera was of the box form usual in detective cameras. It was provided at the front with an opening for the lens and above this with two openings for the finder. At the front there was on one side a lever or button which controlled the shutter and at the back a rod by the movement of which it was possible, without opening the box, to change the plates, a number of which were carried in the magazine of the camera.

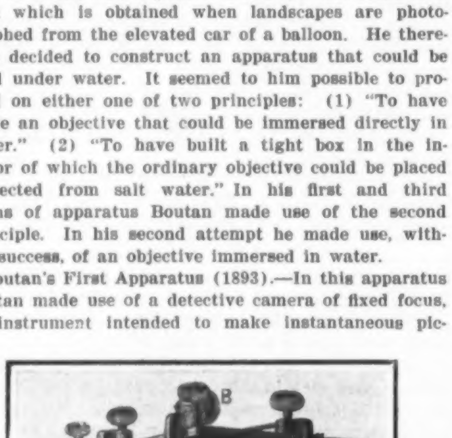


Fig. 7.—Boutan's First Apparatus.

Box used in 1893 for inclosing a detective camera to be used under water. *B*, rubber balloon filled with air; *D*, handle at the back for operating the magazine plate holder; *O*, opening corresponding to the lens; *O B*, handle at the side controlling the shutter; *V*, front finder; *O V*, lateral finder. (Copy of Fig. 1 in Boutan, 1893.)

This camera was inclosed in a copper box (Fig. 7). The top of the box was open and was stiffened by a projecting rim against which a cover could be clamped by means of eight metal screw-clamps. The joint between the rim of the box and the cover was made water-tight by means of a heavy rubber gasket let into rectangular grooves in both the rim and the cover. The box was intended to be used at considerable depths. The pressure of the water on its outside would at 10 meters depth be one atmosphere plus the pressure exerted by a column of water 10 meters high, while the pressure on the inside of the box would be what it was when the box was closed at the surface, one atmosphere. Under these circumstances there was serious danger that the excess pressure on the outside of the box would force the water through between the rim and the cover in spite of the most careful construction of the joint between the two. To overcome this difficulty, however, the cover of the box was provided at its center with an opening which extended upward into a metal tube, and to this tube there was attached an air-filled rubber bag of about 3 liters capacity. When the box was submerged the pressure of the water on the bag was communicated to the air within, so that the pressure on the inner surface of the box was exactly equal at all depths to that on its outer surface. Thus there was no excess pressure on the outer surface of the box to force the water inward against a less pressure within.

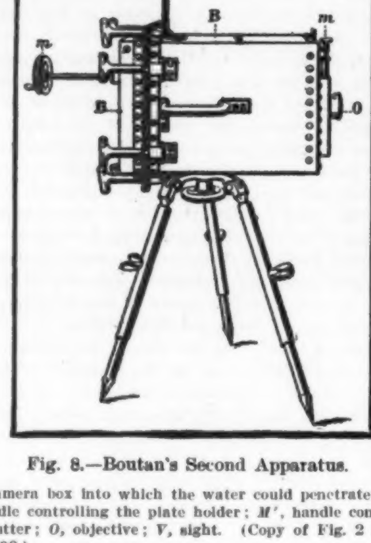


Fig. 8.—Boutan's Second Apparatus.

B, camera box into which the water could penetrate freely; *m*, handle controlling the plate holder; *M'*, handle controlling the shutter; *O*, objective; *V*, sight. (Copy of Fig. 2 in Boutan, 1898.)

The front of the box was provided with three circular openings closed by plates of glass with parallel surfaces. The one at the center was opposite the lens; the two above it were for the finder. A similar opening on one side was also closed by a glass plate and served for the finder. On the same side was a rod which terminated at its outer end in a milled head. Its inner end extended, through a stuffing box which was water-tight, to the interior of the box. By pulling the rod in and out the shutter could be operated. A similar rod at the back of the box could be slid in and out and served to change the plates. When in use the camera was supported on a heavy tripod of iron.

The apparatus was used either while the operator remained in shallow water with his head and shoulders above the surface or when he had descended to the bottom in a diver's suit. When working in shallow water, he put on the diver's suit in order to be protected from the water, but omitted the casque covering the head and the heavy weight ordinarily attached to the back and front of the suit. Thus arrayed, he placed the tripod in position and attached the camera to it. In order to bring the camera to bear on the object to be photographed, it was then necessary to provide a way to determine when the image of the object appeared in the desired position in the finder. This was accomplished by using a metal tube open at both ends, one end of the tube being placed over the ground glass of the finder, and the other, which extended above the water, being applied to the eye. The tube excluded the light from the space between the eye of the observer and the finder, while at the same time the water within it was protected from agitation. By this means it was possible to see clearly the image on the ground glass of the finder. It was necessary merely to manipulate the handle controlling the shutter in order to begin and end the exposure. The plate could then be changed by manipulating the rod at the back of the box and another exposure made at once without taking the camera from the water. Where it was possible to operate near shore, it was unnecessary for the operator to put on the diver's suit or to enter the water. He could set the camera in place from the shore and adjust it or make the exposure while lying upon the bank. Boutan, indeed, made satisfactory photographs of fixed animals in aquaria by immersing this apparatus in an indoor aquarium and operating it by means of a string. By using a very small diaphragm he was able to get clear images of objects at a distance of 15 centimeters from the lens, but this required an exposure of three minutes. He obtained photographs of fish and other mobile forms in the same manner by inclosing the animal to be photographed in a glass globe, which was then immersed in the aquarium at a suitable distance from the lens. The globe served to restrict the movements of the animal. When working in shallow water, he found that the algæ which appear everywhere in the submarine landscape were in constant motion whenever there was any movement of the water. It was therefore necessary to restrict operations to those days on which it was perfectly calm.

In order to obtain photographs at depths at which it was impossible to wade, Boutan made use of the diver's outfit. He describes the outfit in detail and the method of using it in a very interesting section of his paper of 1898. The method of procedure was briefly as follows: The boat containing the apparatus to be used (diver's suit, air pumps, and photographic apparatus) was first firmly anchored at the spot selected and held in place by means of cables stretched to the rocks on shore. The photographer then put on the diver's suit and descended to the point selected as the center of operations. He first signaled to an assistant to let down the photographic apparatus, which consisted of the tripod, the box containing the camera, and a weight intended to steady the apparatus. He then sought out the view to be taken and set up the apparatus at his leisure. This accomplished, he opened the shutter of the camera and signaled to the assistant that the exposure was begun. Since it was impossible to use a watch while under water, it was necessary that the assistant in the boat above should time the exposure. At the expiration of the time agreed upon the assistant signaled and the photographer closed the shutter. When

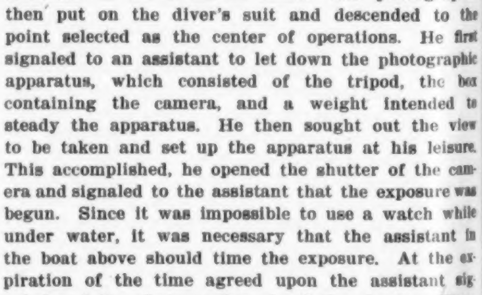


Fig. 9.—Boutan's Third Apparatus (1898).

A, metal camera box; *M*, handle controlling the changing of plates; *M O*, handle controlling the shutter; *O*, opening for the lens; *P*, feet for supporting the apparatus; *V*, sight; *X*, points of attachment of the hood *A B*; *C H*, magazine holder for six plates; *gl*, cleats by means of which the holder glides on a rail inside the box; *pl*, plates; *t*, pin which holds the front plate in place. (Copy of Fig. 3 in Boutan, 1898.)

the weather was good and the sun shining an exposure of ten minutes was necessary with a small diaphragm at a depth of 5 meters. Boutan estimated that at a depth of 10 meters this exposure would need to be more than doubled.

Boutan's Second Apparatus (1896).—This apparatus (Fig. 8) consisted of a metal camera, not inclosed in a box, but intended to be immersed directly in sea

* A reprint of a Bulletin published by the Bureau of Fisheries.

water. The sea water could enter and fill the interior of the camera so that it bathed both the front and back faces of the lens as well as the plates. The latter were contained in a holder which could be attached to the camera after it was submerged. Thus the plates could be changed under water without any risk of fogging them. Sea water was found to have little effect on the plates unless its action was prolonged, and this effect could be wholly prevented by using plates that had been varnished.

The lens used with this apparatus was one intended for use in air, and it was found that good results could not be obtained with it when immersed in water. The success of such an apparatus as this must depend on having a lens especially ground for use under water. No lens of this sort existed and to have one calculated and made would have been expensive. For this reason and for others which he mentions Boutan abandoned this apparatus after trying it for a single season. He says, "The principle is certainly good, and, in spite of the failure that I have made in the application of it, the future of submarine photographic apparatus may lie there."

Boutan's Third Apparatus (1898).—As a result of the failure of his second, Boutan adopted a third apparatus, which was in principle a return to the first. This third apparatus, designed for instantaneous work, consisted of a heavy metal box, shown at the center in Fig. 9. To it are attached four adjustable legs. The box, which is water tight, contains the objective and the plates. It is itself the camera and does not therefore contain within it a camera, to be lifted out and put back. The lens is a Darlot symmetrical-anastigmatic of excellent quality. At the front is an opening (*O*) closed by a plate of glass, through which the light enters the lens. There are no finders and consequently no openings closed by glass plates, with the exception of that for the lens. At the top, in front, is a handle by means of which the shutter may be operated. About the center of the box is clamped a band-iron frame with a ring at the top by means of which the box may be attached to a rope for lifting it in and out of the boat. At the back is a cover which may be fastened by means of screws against a rubber packing on the end of the box, so that the joint between cover and box is made water tight. The rubber bag used in the first apparatus seems to have been found unnecessary and is at any rate omitted. At the back of the cover there projects a handle (*M*) by the manipulation of which the plates may be changed. On the top at *V* is a sight by means of which the camera may be directed at the desired object. Within the box at the back is a magazine plate holder for six plates. This is represented at the left at *CH* in Fig. 9. It is so arranged that when a plate has been exposed it may be made to fall forward by turning the handle shown at *M* in the central figure. A second plate is at the same time pushed into place by springs. When this has been exposed a second turn of the handle allows the plate to fall and a third plate comes into place. Six plates may thus be exposed without opening the box. On each side of the plate holder are two cleats (*gl*). These glide upon two rails on the inside of the box, one on either side, so that the plate holder may be moved back and forth on the rails away from the lens or toward it. By means of a set screw the plate holder may be firmly clamped at any point on the rail. The camera is focused by

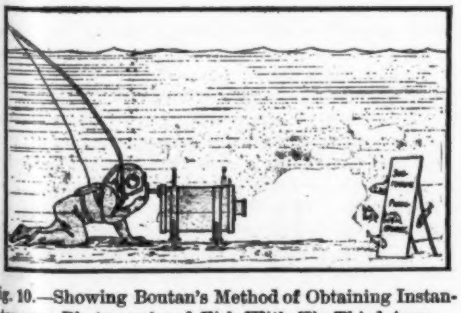


Fig. 10.—Showing Boutan's Method of Obtaining Instantaneous Photographs of Fish With His Third Apparatus. (Copy of Fig. 7 in Boutan, 1898.)

means of this movement of the plate holder. To prevent reflection of light from the lower side of the surface film of the water into the camera there is provided a semicylindrical shade shown at *A B* on the right in Fig. 9. It may be attached to the front of the box above the lens by the arrangement shown at *X*.

It is not possible to focus after the box has been closed in order to immerse it. Consequently one of the rails upon which the plate holder moves must be provided with a scale. The divisions on this scale correspond to different distances between the lens and the object to be photographed. When the plate holder is set at a certain division of the scale the camera is in focus for objects at a distance of 4 meters; when set at another division, for objects at 2 meters. It is therefore necessary to determine before the camera box is closed at what distance the object is to be photographed and to focus by setting the plate holder at the corresponding division on the scale. While the box is immersed this focus cannot be changed. The divisions to be marked on this scale were obtained by focusing on submerged objects while the front of the camera was also submerged. This necessitated the use of special devices, which need not be described here.

This apparatus, which used plates 18 by 24 centimeters (approximately 7 by 9 inches), was so heavy that it required three men to handle it easily in air. On shipboard it was handled by a tackle and swinging boom. It was first lowered into the hold, which could be closed light tight. There the plates were put into the plate holder and this was set at the division of the scale previously decided upon. The

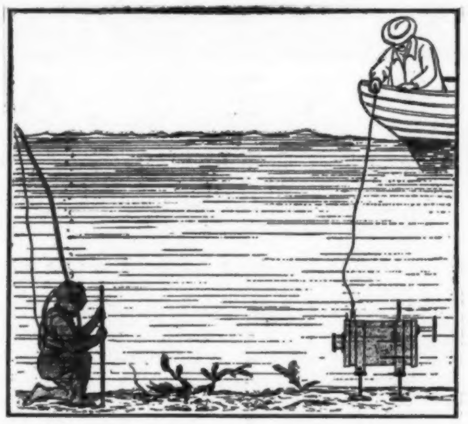


Fig. 11.—Showing Boutan's Method of Operating His Third Apparatus From a Boat by Means of a String. A Diver is Being Photographed. (Copy of Fig. 8 in Boutan, 1898.)

box was then closed water-tight by screwing the cover in place. To remove the moisture from the air within the box and thus prevent its condensation on the lens and other parts within, a wide-mouthed bottle containing quick lime was kept in the box during the intervals when it was not immersed. The apparatus was then hoisted from the hold, swung outboard and lowered to the operator, who had meantime descended in the diving suit and selected the point at which the photograph should be made. It was not very difficult for the operator to handle the apparatus when it was submerged, since it was then buoyed up by the water. It was found easier to move it about when it was suspended by means of a rope to a cask floating at the surface.

The method of using the camera for photographing fish is shown in Fig. 10. The camera, previously set for objects at a distance of 2.5 meters, was placed on a sand bottom at a depth of 3 meters. Here it was either allowed to rest on the bottom on the legs attached to it or was supported above the bottom on a heavy, four-legged iron frame. The camera rested on a platform within this frame and the platform might be so adjusted that the camera could be set at various heights and pointed at various angles up or down. At a distance of 2.8 meters from it was set up obliquely a large white screen of painted canvas stretched on an iron frame provided with feet. This screen served as a background for the fish. To attract the fish the operator then placed in front of the screen at a distance of about 2 meters a bait of crushed sea-urchins and annelids. He then pointed the camera by means of the sight on top and waited until the fish, attracted by the bait, were in such a position as to be in focus, when by means of the handle at the front he made the exposure. The plate was then changed and several exposures made in succession. The screen was useful as affording a contrasting background, but was not considered necessary, since very clear negatives were obtained of fish viewed against the sand or ooze bottom. One of the photographs of fish taken against a screen background is reproduced by heliogravure in Boutan's memoir of 1898. Though the fish were in motion, the outlines of most of them appear sharp against the screen, evidence that the picture was instantaneous. The fish are, however, unfortunately almost wholly lacking in detail. The time of the exposure is not stated, but it was clearly too short to give detail in the shadows.

In Fig. 11 is shown a method adopted by Boutan for operating the camera from a boat by means of a string. In this case the apparatus was first placed in position by the diver, who then withdrew to the distance for which the camera was focused. The operator, who could observe the procedure from the boat, then pulled the string. The resulting picture, which is reproduced in Boutan (1898), is excellent. Subsequently exposures were made from the surface by using a shutter controlled by an electro-magnet.

Boutan's Methods of Artificial Illumination.—Besides his camera, Boutan (1893) describes an apparatus for using a magnesium flash-light beneath the surface of the water. He succeeded subsequently in taking good instantaneous pictures at a depth of 3 meters without artificial light, and estimated that in good weather it would be possible to do this at depths of 7 or 8 meters.

Although his flash-light apparatus proved to be unnecessary in shallow water and was subsequently abandoned as cumbersome and dangerous, it merits a word of description. His figure of it is reproduced in Fig. 12. In its final form it consisted of a cask of about 200 liters capacity closed at both ends, but with the lower end perforated by holes to permit the entrance of sea water. A bell jar of 5 or 6 liters capacity is held tightly against the upper end of the cask by means of the adjustable frame shown in the figure. The cavity of the jar communicates freely through many openings with that of the cask, and both are filled with air. Within the bell jar is an alcohol lamp, and at the side of this is a metal reservoir (not shown in the figure), covered with asbestos and filled with magnesium powder. One end of a metal tube opens opposite the middle of the flame of the alcohol lamp (shown lighted in the figure) and communicates freely with the reservoir above. The other end of the tube extends into the cask, and is there connected to a rubber tube which extends through the side of the cask (at *C* in Fig. 12) and ends in a large rubber bulb. To use the apparatus, the reservoir is filled with magnesium powder and the alcohol lamp lighted, then the bell jar is fastened in place and the cask, heavily weighted at the bottom, is lowered into the water and set wherever needed. The air in the bell jar and cask is enough to keep the alcohol lamp burning for some time. To produce the flash it is merely necessary to press the bulb, when the magnesium powder, which has fallen from the reservoir into the tube, is blown against the flame from the end of the tube and ignited. This operation may be repeated as long as the lamp remains burning and the reservoir contains magnesium. It is of course necessary to operate the shutter of the camera simultaneously with the flash.

Boutan (1900) describes and illustrates another illuminating apparatus which consists of two powerful arc lamps inclosed in water-tight jackets of heavy metal, designed to withstand the pressure of the water at a depth of 50 meters or more. Each jacket was pierced by an opening into which was fitted a condensing lens, by which the emerging light was concentrated upon the object to be photographed. The two lamps were rigidly attached to the camera support and were supplied, through a cable, with current from storage batteries on board the boat. The same cable carried also an insulated wire through which an electro-magnet actuating the shutter of the camera could be controlled. The camera with lamps attached

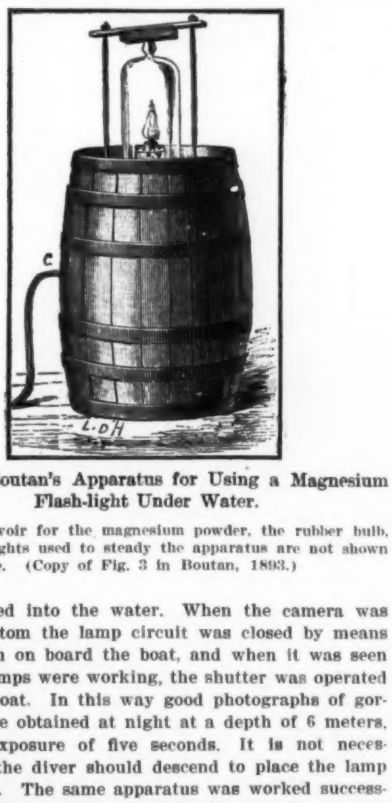


Fig. 12.—Boutan's Apparatus for Using a Magnesium Flash-light Under Water.

The reservoir for the magnesium powder, the rubber bulb, and the weights used to steady the apparatus are not shown in the figure. (Copy of Fig. 3 in Boutan, 1893.)

was lowered into the water. When the camera was on the bottom the lamp circuit was closed by means of a switch on board the boat, and when it was seen that the lamps were working, the shutter was operated from the boat. In this way good photographs of gorgonias were obtained at night at a depth of 6 meters, with an exposure of five seconds. It is not necessary that the diver should descend to place the lamp in position. The same apparatus was worked successfully at a depth of 50 meters, in this case the apparatus not being allowed to rest on the bottom, but being held suspended from a cable at some distance from the bottom. The object photographed was a canvas screen rigidly attached by rods to the camera support at such a distance from the lens as to be

sharply focused. When the apparatus was brought to the surface it was found that one of the lamps had failed to withstand the pressure so that its jacket was filled with water. With lamps and camera constructed to withstand the pressure at great depths, Boutan believes that an apparatus of this sort may be used at depths to which light does not penetrate. The apparatus may of course be used by a diver at depths of 40 meters or less, and the camera may then be directed at any desired object; but at greater depths a diver cannot work, and the apparatus must then of course be let down at random, to photograph only what chances to be in the range of its lens.

Boutan's work has the great merit of having demonstrated that it is possible at a depth of 3 meters to obtain good instantaneous pictures by the light of the sun and without the use of artificial light. He showed further that his apparatus with electric illumination could be immersed and operated from outside the water at depths as great as 50 meters. For work at great depths or by artificial light no better apparatus is known. The faults of it, for work in shallow water or at any depth to which a diver can descend, are (1) its great bulk and weight, and (2) the fact that it cannot be focused under water. It cannot be carried about freely, and for use it must be set on the bottom at a known distance from the object to be photographed and must then be sighted at that object. It is unfortunate that for work in shallow water Boutan did not make use of the principle of the twin camera or the reflecting camera, for by using either of these devices he could have made an apparatus that was portable and that could have been focused under water. He could thus have carried his camera about as one carries detective cameras and could have photographed submarine objects either while wading with his head above water or in moderate depths while on the bottom in a diver's suit.

Bristol's Subaquatic Camera.—That such a method is feasible and that it may yield better results than those obtained by Boutan was suspected as early as 1898 by Prof. C. L. Bristol, who immediately began work on a submarine photographic apparatus. Nothing has as yet been published concerning this apparatus, and the details of its construction are quite unknown to me. Prof. Bristol kindly permits me, however, to make the following quotation from a letter to me on the subject: "From the first I have used a water-tight camera capable of submersion in from 10 to 15 fathoms, mounted on a tripod with a universal motion, arranged so as to show the picture on the ground glass as well as to focus the lens and make the exposure. Moreover, a magazine attachment permits me to carry down several plates and to change them after each exposure while under water. After several season's efforts the apparatus is now very efficient and has produced excellent results. I am not yet ready to publish a detailed account."

(To be continued.)

ANIMAL FATS AND OILS.

SOME MANUFACTURING PROCESSES.

BY W. H. BENTLEY.

The sources of the animal oils of commerce, excluding the fish oils, are fats—commercially known as greases—produced by packing houses, rendering establishments, and tanneries. The generic terms lard oil, neatsfoot oil, and tallow oil comprise grades ranging respectively from the finest oil made from edible lard and called in the trade prime lard oil, edible tallow, and pure hoof oil, down to oils pressed from offal greases, and from the greases obtained from the hides of cattle and other animals, in tanneries and skin dressing establishments.

The first qualities of fats, respectively known in commerce as prime lard and edible tallow, according as they are obtained from the carcasses of hogs or cattle, are familiar to every housekeeper. Wherever they are produced for sale to the public, the most exacting hygienic conditions must be observed under governmental inspection, which requirement is of comparatively recent enactment. As these two articles now come into the market, they are likely to be made of strictly edible stock, cleanly rendered, and to be pure. This statement should be modified in respect to what is known as "compound lard," an article composed of tallow stearine—pressed tallow—cotton seed oil, and a certain percentage of lard. This article is of stiffer consistency than lard, and is exported to tropical countries where the high temperature would reduce pure lard to the consistency of an oil, in large quantities. The components of compound lard are edible, and it is cleanly made under governmental inspection; but obviously, it is not pure lard.

The inedible grades of hog fat below prime lard are designated by commercial terms, such as "choice white," "A white," "B white," "yellow," "brown," etc. Their respective market values depend on color, odor, percentage of free fatty acid, and other varying qualities. They are purchased not alone by the oil presser, but also by the soap maker; though the one may make his selection with a view to requirements that are not considered by the other.

The lower, non-edible grades of tallow also have their respective trade designations, and are mostly taken up by the soap and candle makers, though tanneries, leather dressing establishments, and compounders of lubricating greases also use considerable quantities. Beef fats—tallows—contain but a comparatively small amount of oil that is of value to the oil presser, and are, therefore, but little pressed, with the exception of the edible grade from which oleomargarine is made. A beef fat oil commercially known as acidless tallow oil, is merely tallow, generally of an inedible quality, from which the free fatty acid has been extracted. This so-called oil is much used by lubricating-oil and grease compounders in preparing high-class lubricating compounds.

Edible tallow selected for the production of oleomargarine, after being rendered, is allowed to "seed" or grain from a liquid condition into a semi-liquid state, wherein the stearine appears much like separated fish spawn, mixed with oil. The seeding is accomplished by maintaining the room in which the process is carried on at a comparatively high temperature. After the desired result is obtained, the semi-liquid mass is transferred to bags and hydraulically pressed. The oil thus obtained is very similar to butter fat in its properties, and solidifies at a temperature but a little below that at which tallow solidifies. This oil is added to milk or cream, and the mixture, when churned, yields the article variously known as oleomargarine, butterine, etc. The stearine remaining in the bags after the oil has been pressed out, known in the trade as "oleo" stearine, being very hard, is the article used by makers of compound lard to stiffen their product.

From the rendering establishments are obtained horse grease, bone grease, garbage grease, fertilizer grease, offal grease, etc., each suggesting its original source, and each containing an oil that has qualities of value for one purpose or another.

"Crackling" grease is a product from the cracklings—scrap remaining from rendered lard. It contains a large amount of oil low in free fatty acid, but dark yellow in color. As the source of this grease would indicate, its odor is inoffensive.

Fleshing grease is a by-product of the tanneries, and when it is considered that its source is the small bits of flesh adhering to the inner surface of hides of cattle, the quantities of it that reach the market are surprisingly large. "Coon" grease is produced in skin dressing works, from the fleshing of skins of fur bearing animals; and besides being very dark in color, has a decidedly unpleasant, "skunky" odor. However, it contains an unusually large percentage of oil of heavy body, that has very useful properties for some purposes.

Grease rendered from the fleshings of sheep skins, unlike mutton tallow, is very soft, and therefore contains a large percentage of oil. It has the strong, distinctive odor of unwashed sheep, but, being fairly light in color, commands a good price. A dark, chocolate colored grease obtained from the wool of sheep is commercially known as degras—pronounced degraw. This grease is seldom pressed but is mostly used as it comes from the producer, by tanners and leather dressers, though also used to some extent by lubricating grease compounders.

Pure neatsfoot grease, made from the lower leg bones and feet of cattle, is almost wholly oil, of a golden yellow color and not unpleasant odor. It is very carefully rendered at a comparatively low temperature, in order to prevent the dissolving into it of the mucilaginous matter that also occurs in the feet of cattle. High temperature in rendering would be likely to set free this extraneous matter, which would then be present in the oil, much to the detriment of its quality. This grease is the source of the only strictly pure neatsfoot oil to be obtained. Practically an oil itself, it may easily be bleached almost colorless. When properly rendered, it contains but a very small percentage of free fatty acid, and is the most expensive oil of its class. By pressing neatsfoot grease that has been solidified by low temperature, an oil that will remain limpid at so low a temperature as 10 degrees above zero, Fahrenheit, may be obtained.

Oils commercially considered in the neatsfoot class are made from fleshing, and even from glue greases, the latter being a by-product of the glue factories. Superior qualities of fleshing greases furnish an oil that very closely approximates pure neatsfoot oil; but the general run of so-called neatsfoot oil made from fleshing greases is not alone darker in color than the pure oil, but is also deficient in other desirable qualities that true neatsfoot exhibits.

The connective tissue of fat as taken from an animal, as well as adhering muscular tissue, rapidly decomposes, especially in warm temperatures. The process of decomposition produces what is known as free fatty acid that is readily assimilated by the rendered fat. When the fat is pressed, a large percentage of the fatty acid passes into the oil. Its presence cannot be detected by any means except a chemical test. It is a troublesome factor to the oil presser, since, when present in any considerable quantity, it greatly reduces the value of his oil. Oil containing it will not burn well, since it causes excessive charring of the wick. It reduces the efficiency of an oil as a lubricant, even injuriously affecting metals after a time. It impairs the value of an animal oil as a dressing for leather. It occurs not alone in animal oils, but also in vegetable oils, olive oil "foots" sometimes consisting of as high as seventy-five per cent of fatty acid.

For the most exacting and particular uses, such as the compounding of high-class lubricating oils, it is essential that an animal oil shall practically be free from fatty acid. Fortunately, it may practically be removed from oil by the use of a caustic alkali, for which it has an affinity; or, it may be removed from a grease before being pressed, by the same method. When the alkali in liquid form is introduced into the oil, the combination of the fatty acid and the alkali forms a soap that readily separates from the oil, from which it may then be removed. Fats freshly rendered before decomposition sets in, contain but little fatty acid. Prime lard and edible tallow contain but insignificant quantities of it.

Offensive fats may be purified and bleached by several methods well known to the trade. By one method, the melted grease is vigorously boiled with live steam, and while in violent ebullition, diluted sulphuric acid is added to it. The acid readily separates from the grease after boiling ceases, and may then be drawn off from the bottom of the tank. Repeated washing with water removes all traces of the acid. The most common method of bleaching is to add fuller's earth to the melted grease, and incorporate it with the grease by agitation. The fuller's earth is subsequently extracted from the grease by means of a filter press, through which the mixture is forced by a pressure pump. Offensive greases thus treated are not alone sterilized, but also lightened in color and rendered almost neutral in odor. Absolutely pure fat, whatever its source, is colorless, tasteless, and odorless; but no absolutely pure fat is commercially produced. Even the agreeable, nutty odor of freshly rendered steam lard is due to the presence in the lard of foreign matter.

One of the commercial requirements laid down in the marketing of animal oils, is that they shall remain limpid at a given temperature to be classed as "winter" oils; and at a somewhat higher temperature if falling under the classification of "summer" oils. Melted grease, when filtered, has the clear and brilliant appearance of the oil that may be pressed from it; but when subjected to a sufficiently low temperature, becomes opaque and solid. In order to obtain "strong" oils, as winter oils are called, it is necessary to chill the greases from which they are pressed down to a temperature sufficiently low to produce solidification. Most pressers maintain a refrigerating plant, by means of which greases are properly chilled to a uniform temperature at all seasons of the year, thus enabling them to produce a winter oil even in the summer season.

Greases are mostly sold to the trade by brokers, to whom the manufacturer or renderer supplies samples in sufficiently large quantities to enable the brokers to distribute testing quantities to prospective buyers; and when purchase is made, the lot delivered is assumed to be identical in quality with the sample. The rules of the exchanges, in accordance with which most sales are made, provide that grease may contain not to exceed 2 per cent of moisture and impurities. By agreement between purchaser and seller, the percentage of a given lot may be greater or less than

this amount; but the exchange rule holds when there is no special agreement, which is most frequently the case. In case of dispute over quality, samples of the lot are taken by a licensed inspector, who delivers them to the official analyst of the exchange and upon the report of the analyst, a settlement is generally effected. The court of last resort is the complaint committee of the exchange; and a refusal to accept its decision would subject the offender to disbarment from exchange privileges.

Even carefully rendered greases contain a small percentage of moisture and impurities, the latter consisting of particles of muscle and tissue; the former occurs by reason of carelessness in drawing the grease from the rendering tank. The loss to the presser from moisture and impurities is considerable in the course of the year. In disposing of his by-product—stearine—he is allowed the same privilege in regard to moisture and impurities that the renderer is allowed; but his oil would be unsalable if not absolutely clean and clear.

Greases, superficially speaking, are composed of olein and stearine; from each of these components an almost endless list of fatty acids and glycerides may be separated. But with these the presser has no concern; he merely mechanically separates the olein from the stearine, to a certain extent, in suitably constructed presses. The stearine goes to the candle or soap maker, the latter of whom again chemically separates the stearine, obtaining elaine or "red" oil, and stearic acid. In his process, he incidentally obtains as a by-product crude glycerine, that, after being refined, appears in the drug shops, at which it is sold for toilet and medicinal purposes.

The oil produced by the presser is sold to textile mills, lubricating oil compounders, tanners, and leather dressers. Aside from prime lard oil and oleo oil, of which mention has already been made, none of the commercial lard, tallow, or neatsfoot oils is edible. The edible grades mentioned may not be lawfully sold under their respective brands, unless packages that contain them bear the government certificate. Even the non-edible greases and oils must be branded "inedible" when exported from the State in which they were made, to another, or when exported out of the country.

At the textile mills, the animal oils are saponified with a mild alkali, a sort of soft soap in liquid form being thus produced; this is thrown or sprayed on the wool, cotton, silk, jute or hemp, as the case may be, during the process of its manufacture into a fabric, in order to prevent the adherence of the fibers to one another. The physical construction of most natural fiber exhibits one section after another successively protruding from the one preceding it, like those of the bamboo. The roughness that occurs at the joints is the cause of adherence that, without the use of oil prepared in the manner mentioned, would cause the fabric maker endless trouble.

The lubricating oil compounders add varying quantities of animal oil to the petroleum oils, to obtain "body" in the lubricating mixture. The better qualities are also added to a certain grade of petroleum, to produce the signal oils used in railroad service. Lighthouses also use an oil of which animal oil is an ingredient. The present price of petroleum as used for lubricating purposes is not more than one-fourth that of the cheapest grade of lard oil.

Although grease oils exhibit properties that make them more effective as lubricants than the petroleum products, unlike the petroleum oils they readily oxidize. Oxidation solidifies them, thus producing a gum that increases rather than reduces friction. A mixture of the two oils is, therefore, essential when producing the better class of lubricants; the animal oil supplies the body, while the petroleum prevents oxidation. On light bearings, the use of petroleum alone might be sufficient.

The comparative high cost of animal oils sometimes tempts unscrupulous manufacturers and dealers to adulterate them. Cottonseed oil at one time was a cheap and convenient adulterant, much used; but its present high cost militates against its economical use in the lower grades of animal oils. Its yellow color precludes its use in the better grades. Rape seed oil was also much used as an adulterant at one time; but, like cottonseed oil, it is now too expensive for the purpose. Corn oil, made from the heart of the corn kernel, is now inexpensive enough to serve the adulterator, and is more or less used by him. Neutral petroleum also sometimes shows its presence in animal oils when they reach the consumer; and of late, an almost odorless and tasteless seal oil has appeared in the trade, one recommendation (?) for which is, that it may safely be used in adulterating lard oils.

The detection of some adulterants is difficult, even for those experienced in the business. This is particularly true of cottonseed oil, since the fat of hogs fed on cottonseed cake or meal will show chemical reactions similar to those shown by the presence of adulterating cottonseed oil. The presence of paraffine oil in an animal oil may readily be detected, if the quantity be of consequence, by the "bloom" or bluish green color of the mixture, and by the persistence of air bubbles on the surface of the oil after being violently agitated. Air bubbles very quickly disappear from the surface of an agitated animal oil that is strictly pure. The large users of animal oils, such as the textile mills, now employ an analyst; and for this reason, if for no other, adulterated oils are seldom offered to them. The small consumer, with no knowledge of or facilities for testing oils, is, therefore, the more likely victim of the adulterator.

Correspondence.

CURIOUS PROPERTIES OF NUMBERS.

To the Editor of Scientific American Supplement:

Noticing lately some articles concerning the properties of the squares of numbers, I thought I would write and call attention to some peculiarities that might be interesting.

For instance your correspondent says that it has been denied that any number whatever can be the difference between two squares. It seems strange that certain facts should have been overlooked. For instance:

Let $x^2 - y^2$ denote the difference between two squares. This expression can be resolved into two factors, $x + y$ and $x - y$. That is, $x^2 - y^2$ equals $(x + y)$ $(x - y)$. That is, the product of the sum and difference of two numbers is equal to the difference of their squares. Half the sum added to half the difference equals the greater number, and half the sum less half the difference is the less number. Now every number has at least two factors, itself and unity. Hence to find two squares whose difference shall be a certain number it is only necessary to take two factors, and let the larger be called a sum and the smaller a difference between two numbers.

For example, to find two numbers the difference between whose squares shall be 37, we let $x + y$ be 37 and $x - y$ be 1, which are the only numbers whose product is 37. By resolving the equations

$$x + y = 37$$
$$x - y = 1$$

in the usual way we find that x is 19 and y 18, and the difference between the squares of these two numbers will be found to be 37. If we wish to find two numbers the difference of whose squares shall be 1 we shall have to use fractional numbers, of course. With this exception we can proceed in the same way with all numbers, only taking care that both factors of any given number be odd or even, in order that their sum and difference may be even.

Again the square of x is x^2 and the square of $x + 1$ is $x^2 + 2x + 1$. Therefore $2x + 1$, the general expression for odd numbers, is the difference between two consecutive perfect squares. Therefore every odd number is the difference between at least two perfect squares, and the sum of consecutive odd numbers from 1 up will always be a perfect square. This can be easily proved by taking the first ten numbers and the squares, as follows:

	1	2	3	4	5	6	7	8	9	10
	1	4	9	16	25	36	49	64	81	100
(Diff.):	1	3	5	7	9	11	13	15	17	19

As will be seen, the second row is composed of squares of the first, and the third row is differences between successive squares, and comprises every odd number inclusive. If we begin with one, and add the numbers in the third row, we will get perfect squares continually. If we produce the lists indefinitely we will get the same result.

By the expression $2x + 1$ we can easily find the two perfect squares between which any odd number lies. If we make $2x + 1$ equal 101, for example, by transposing 1 we get $2x$ equal 100, and x equals 50; therefore $x + 1$ equals 51. The square of 50 is 2,500, and the square of 51 is 2,601; their difference is 101.

By making the expression $(x + y)$ $(x - y)$ equal a perfect square we have an easy means of finding two perfect squares whose difference is a perfect square.

Louisville, Ky. A. Y. Smith.

THE PASSING OF THE WHALE.

To the Editor of Scientific American Supplement:

In the Scientific American Supplement for March 13th, Mr. J. A. Mörch criticises my article on "The Passing of the Whale," taking issue with my statement that there is any danger of serious diminution in the numbers of the finner whales. Mr. Mörch says that the situation on the Newfoundland coast is exceptional, and that elsewhere the whales are in no danger. We are familiar with similar statements in regard to the bison, the passenger pigeon, and our "inexhaustible" forests.

Mr. Mörch ascribes the scarcity of whales on the Newfoundland coast to a corresponding scarcity in the plankton. This, it may be said, is pure theory. We know nothing of the conditions of the plankton along the Newfoundland coast and very little of it anywhere. Recent observations show that the plankton life is by no means as extensive and as widely distributed as has hitherto been assumed.

A little farther on we are told that the whaling grounds of the North Atlantic cannot compare with those of the Southern Hemisphere, which are practically untouched. In support of this Mr. Mörch quotes the remark of Capt. Strumme to the effect that "it is nothing but whales in those waters; there are the narwhal or unicorn whale and humpback."

In regard to this it may be said that the narwhal does not occur in the Antarctic seas and has never been an object of commercial pursuit anywhere. There is no reason to suppose that whales are any more abundant in those waters than they once were in the Bay of Biscay, on the Newfoundland coast, and at other localities in the Northern Hemisphere. The value of the average man's estimate of numbers is shown by the remark of the commander of an English gunboat stationed in Bering Sea. He visited St. Paul Island and was taken to Kitovi rookery, where looking down upon the seals he remarked in astonishment "There are millions of them!" As a matter of fact there were by actual count something over 3,000 seals on this rookery at this time.

The remark that the humpback is one of the most prolific of whales is misleading, for like other whales, this species rarely produces more than one, and never more than two at a birth and this at long intervals.

We are told that there is no danger of too many whales being killed, as the demand for oil is limited. Limited as this demand may be, it has never yet been satisfied and is growing all the time. It is likely to be increased when our "limitless" stores of petroleum begin to give out. Furthermore, the value of the whale's bone and flesh for fertilizer is probably as great as the value of the blubber for oil and there are still further possibilities in the way of glue and leather and very likely meat.

To recapitulate a little, it may be said that the bowhead is on the verge of actual extermination, and that the right whale has been commercially exterminated in the Northern Hemisphere. Owing to cessation of whaling, it has recuperated in the South and is now being killed down for the second time. It took a very short time to commercially exterminate the gray whale on the coast of California, and nothing but the discovery of petroleum saved the sperm whale from commercial extermination; so early as 1850 whalers were beginning to deplore the growing scarcity of whales, wondering what we should do for light when the supply failed.

The ease with which the humpback may be taken is shown by the fact that in 1908 two whalers on the Pacific coast took respectively 318 and 285 whales, mostly humpbacks.

Last July a whaling station was opened at Delagoa Bay, Africa, and by the middle of September the single vessel employed had captured 104 whales. In the face of these figures it is idle to say that the numbers of the whales are not rapidly diminishing.

What has happened on the coast of Norway and the coast of Newfoundland will inevitably happen at every place where whaling is actively pursued, and it is just as well for those investing in the whale fishery to remember that there is no such thing as an inexhaustible supply of whales. Those who are first in the field will undoubtedly make large sums of money, but those who undertake the business later on should go over the ground carefully before investing their money. F. A. Lucas.

Brooklyn, N. Y.

The researches made in France by Messrs. Tarbouriech and Saget show that there is a somewhat curious iron product contained in the plant *Rumex obtusifolius*. It is the plant containing the largest amount of iron of any which we know, and the dry root contains nearly one-half per cent of iron. Micro-chemical research shows that the iron is not revealed by ordinary analysis, but is contained in the plant in the masked state and in a compound which is shown to be of an organic nature. However, it is very difficult to extract it from the plant. The authors succeeded in doing so, and it consists of a mass of brilliant black scales of a hard nature. It burns with incandescence, giving off the special odor due to nitrogenous compounds. Analysis shows that it contains carbon, hydrogen, nitrogen, phosphorus, iron, and oxygen. They suppose that this body has a close analogy with the iron compounds obtained from the *nucleons* of Siegfried which are so largely distributed in the bodies of animals, in the muscles and also in milk. These nucleons are generally considered as the agents which are charged with transporting in the animal economy the iron, phosphoric acid, and lime. This seems to be borne out by the striking results which the new body gives when administered as a tonic for the system. Such a substance may thus prove to be of much value in the way of furnishing iron to the blood.

ENGINEERING NOTES.

U. S. naval vessels under construction numbered 33 at the end of February. Of this number six are battleships, of which four are approximately 75 per cent completed, and the other two just started; 15 are torpedo-boat destroyers, of which five are more than half completed; eight are submarine torpedo boats, seven of which are about three-quarters completed; two are colliers and two are tugboats, all four of which are nearly ready for commission.

Mr. O. M. Leighton, chief hydrographer, and A. H. Horton, in Forest Service Circular 143, have shown that it is perfectly practicable, in connection with the forestry service, to make larger or smaller lakes in the up-country and impound the water, so it will be held back in time of flood, and thus save the immense loss and damage that annually occurs on the Ohio and Mississippi rivers and, at the same time, produce invaluable water powers and navigable rivers all through the dry summers. What is true of these rivers is true of every river in the country to a greater or less extent. This is further elucidated in Forest Service Circular 144, both of which circulars can be secured from the United States Department of Forestry.

Some of the native Australian woods have a very high tensile strength. The Practical Engineer states that the blue gum of Tasmania has an ultimate strength of 29,800 pounds per square inch, and weight for weight has 2.3 times the strength of nickel steel. The modulus of elasticity is 3,500,000. The swamp gum, red gum, and salmon gum wood, also Australian native woods, have a tensile strength of about 20,000 pounds per square inch. Weight for weight, the swamp gum wood has double the strength of high-grade structural steel. While the tensile strength of these woods is high, the shearing strength is low as compared with steel as it does not exceed 2,000 pounds per square inch for any of the woods mentioned.

The Special Committee appointed by the American Society of Civil Engineers to report upon the design and strength of steel columns and struts recommended the building of a machine capable of testing to destruction full-size compression members of large dimensions. One result of the report is the introduction of a bill providing for the construction by the government of a testing machine capable of making tension tests up to 11,000,000 pounds, and compression tests up to 22,000,000 pounds on members 100 feet long. As was mentioned on a previous occasion, the United States Geological Survey will soon possess a compression testing machine of 10,000,000 pounds capacity, but this gigantic appliance will be quite eclipsed if the present bill should be passed. If a similar proposal were brought before the British Parliament it would have a very chilling reception from the Treasury bench, by whose occupants expenditure in aid of applied science has never been favored as it is in America and in various Continental countries.

Mr. Sherard Cowper-Coles has recently taken out a patent in Great Britain for the following process for the manufacture of smokeless fuel: About one-third part by weight of wet peat and two-thirds part by weight of bituminous coal in a finely divided state, are placed in a retort and heated to a temperature sufficiently high (about 850 deg. F.) to drive off those hydrocarbons that produce smoke, the generation of the steam from the peat assisting in this operation. It will be understood that the temperature is not raised materially higher than is necessary to drive off the hydrocarbons, as above stated. The heat is applied for about five hours. The bituminous coal binds the peat together to a coherent mass and forms a fuel of high calorific value, which is readily ignited in a grate in the ordinary way and burns economically and without smoke. In practice the retort may be provided with relief valves and arranged so as to maintain a pressure of 10 pounds per square inch. The retort may also be fitted with a plunger which is forced to one end when the contents are in a plastic state, and it may be heated in any convenient way, such as by heat externally applied or by burning some of the gases generated after partial purification. The watery extract, containing tar of complex constitution, pyroligneous acid, and other products derived from the carbonization of peat, in addition to the gases above referred to, is advantageously condensed and utilized for the production of a pitch of superior quality, and the usual condensable products obtained from the bituminous coal in the retort may be collected and used for any desired purpose. In some cases the contents, after the above described process has been completed, may, either while still hot or after they have cooled, be discharged into a solution of calcium chloride. By this means the smokeless fuel is rendered slightly deliquescent and always retains a certain quantity of moisture. The coal or the peat, or both, may also be moistened with a solution of calcium chloride before being placed in the retort.

ELECTRICAL NOTES.

The only practical processes for producing zinc by electrolysis employ sulphuric acid as the solvent. The roasted ore is leached with dilute sulphuric acid, and the resulting solution is purified and subjected to electrolysis. After the removal of the zinc the liquid is poured upon a fresh portion of roasted ore and is thus used repeatedly. It is possible, by careful attention to all necessary details, to produce about 3,100 pounds of zinc of a purity of 99.97 per cent in one year from one horse-power. The electrolytic method is advantageous in mountainous regions with abundant water power, and is especially desirable for poor ores, for which the distillation process is costly and wasteful.

The substitution of tungsten lamps for carbon incandescent lamps, particularly where the change has been made on a lamp-for-lamp-basis, has resulted in such a radical improvement in the illumination of the public thoroughfares electrically lighted that a considerable extension of this form of lighting for streets and roadways in suburban and residential districts will undoubtedly follow. The energy for this form of street lighting is usually obtained from an overhead distribution on the alternating-current series system, both arc and incandescent lamps receiving energy from the same circuits, and any increase in this form of lighting will undoubtedly be an extension of this system.

When installing storage batteries, they must be thoroughly insulated from the floor, and there are several methods that may be employed for this purpose. Two tiers of porcelain insulators may be used, the first tier being mounted on brick piers capped with hard-pressed tile, and the first tier of insulators, which should be of the triple-petticoat pattern, placed on top of this tile. On top of these insulators two sticks are placed, and preferably covered with acid-proof paint. Above these sticks are placed three tiles, and on top of these tiles a second row of porcelain insulators, which support the battery tank. In this case the bottom of the tank will be some 21 inches above the floor. The floor should be made of glazed tile or vitrified brick, with joists of asphalt, as the cement is attacked by the sulphuric acid which may leak over from the cells.—Practical Engineer.

Space telegraphy by means of ultra-violet rays is carried out by J. Köhler in Germany. If two poles of a frictional electric machine are connected to two metal points facing each other, such as needle points, these will pass a silent discharge between the points. As such discharge is sensitive to ultra-violet rays, if we let fall rapidly repeated rays on the points we can hear a sound in a telephone which is connected across the latter. M. Köhler's apparatus consists of a receiver of this kind and a transmitter at a distance which has a source of ultra-violet light and a rapidly-revolving disk provided with holes, so that there is sent out a rapid series of light impulses and these fall upon the receiver. We hear a continuous sound in the telephone corresponding to the rate of the impulses. Signals by dot and dash can then be sent by covering and uncovering the rays with a piece of cardboard. He was thus able to send letters and afterward entire sentences.

An important paper entitled "Electric Traction Vagabond Currents" was recently read by Mr. J. G. and Mr. R. G. Cunliffe to the Manchester local section of the Institution of Electrical Engineers. It seems to us that there is no necessity to imitate the Germans and call "stray" or "leakage" currents "vagabond" currents, and we are sorry that electricians are adopting the latter adjective. In tramway systems the electric current, after passing through the motors, enters the rails by the wheels, but unfortunately it does not confine itself to the rails, but a large fraction of it leaks to the "earth," and returns to the power station by the path of least resistance. Thanks, however, to the strict regulations of the Board of Trade, there has been very little electrolytic damage done in Great Britain. The authors point out that it is necessary to take the greatest care in the car sheds, as the stray currents often do considerable damage to pipes imbedded in concrete which is often wet. Damage done to these pipes is very costly to repair. One interesting point which is clearly brought out in the paper is that the leakage currents from the rails are responsible for the excessive magnetic disturbances often produced by tramway systems. The necessity for an insulated return in the neighborhood of a magnetic observatory is therefore clearly proved. From numerous tests which they made on earth conductivity the authors conclude that it is invariably of an electrolytic nature, and hence corrosion of the pipes can always occur. They state that it is the custom of many waterworks engineers to judge of the safety of their pipe systems by the positive voltage difference between them and the rails. The authors state that the higher this voltage the safer the pipes. We think that this is wrong, for it is at those sections where the stray currents leave the pipes that they get eaten away. It would be easy to maintain the pipes artificially at a voltage less than that of the rails, and in this case there would be no danger.

TRADE NOTES AND FORMULÆ.

Malt coffee (Kneipp's) is produced by making an aqueous extract of unroasted coffee, or of the refuse obtained in the preparation of the coffee bean, preparing by hot extraction an aqueous extract of raw, unroasted coffee constituents and therewith impregnating the unroasted malt or grain, a roasting in the customary manner following.

A solvent for dried oil paint is 50 per cent crude carbolic acid. To insure a more active effect, take so-called 100 per cent crude carbolic acid. Brushes containing hardened oil-paint should be soaked several days in crude, 50 per cent carbolic acid, and then washed with water. Acetate of amyl is also an excellent solvent of resinified oil.

Almond Paste, Perfumed (substitute).—50 parts of calcined soda, 100 parts borax powder, 200 parts finest orris root powder, and 2,000 parts of the finest wheat or rice flour are mixed, and with this mixture, 120 parts of fatty almond oil uniformly rubbed down. Finally, 100 parts of spirit and about 50 drops of oil of bitter almonds are added, the whole being rubbed through a medium fine hair sieve.

Olivat, Mixture for Greasing Wool (by Jüngst and Heinzerling).—Pulverize 1 part American rosin, with 1 part spirit of sal ammoniac free from lime, and 10 parts of water, stirred together cold, until a jelly-like mass is obtained. To purify it from unconverted rosin, etc., pass this mass through a fine sieve and the mixture, thus purified, is mixed with one part of rape oil, oleine, etc., or a similar fatty oil, suited for greasing wool, to form a homogeneous emulsion, to which 1/100 part of glycerine may be added. When using, add to this emulsion about half the quantity of water and use it in this form for greasing the wool.

Magnesium Torches.—Melt together 2 parts of shellac with 1 part of rosin, powder the molten mass, which has been poured onto a sheet of metal and allowed to cool and utilize it in the following manner: For white flame: 200 parts rosin mixture and 1,400 parts nitrate of barium are carefully melted together, so that no fumes of decomposed rosin arise. The molten mass is allowed to cool, is pulverized, sifted and mixed with 35 parts of magnesium powder. For red flames: 160 parts of rosin mixture, 40 parts of first melted and then pulverized chloride of strontium, 800 parts of nitrate of strontium and then 25 parts of magnesium powder. The powder is placed in tubes 1½ meter long (59 inches) and 2 centimeters (¾ inch) thick of thin sheet zinc, which, as the red flame mixture readily becomes moist and then will not burn, must be well closed with corks. The ends are protected from moisture by dipping in melted paraffine.

Cork-Wood Mass.—The production consists in the mixture, compounding, and kneading together of more or less finely granulated cork-wood, silicate of soda, and heavy spar, for use for various insulating purposes, such as the insulation or covering of steam boilers and heating pipes, the lining of walls in ice-houses, etc. The preparation of such a mass or pipe covering is effected by first mixing the silicate of soda, which has been stirred with water, into a paste with pulverized heavy spar, then adding the granulated cork and then pouring the thoroughly kneaded mixture into molds rinsed out with melted sulphur. For the production of 1 cubic meter (1.308 cubic yard) of such a cork mass, there will be required 90 grammes of granulated cork, 140 grammes of silicate of soda, 170 grammes of heavy spar. Dried in the air, the weight of the resultant product is reduced to one-fourth of the total weight of the separate constituents. If we wish to obtain a heavy product, of equal magnitude, we need only increase the weight of the silicate of soda and heavy spar to a corresponding extent. The chief properties of this mass are that it is a bad conductor of heat and electricity and impervious to sound.

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